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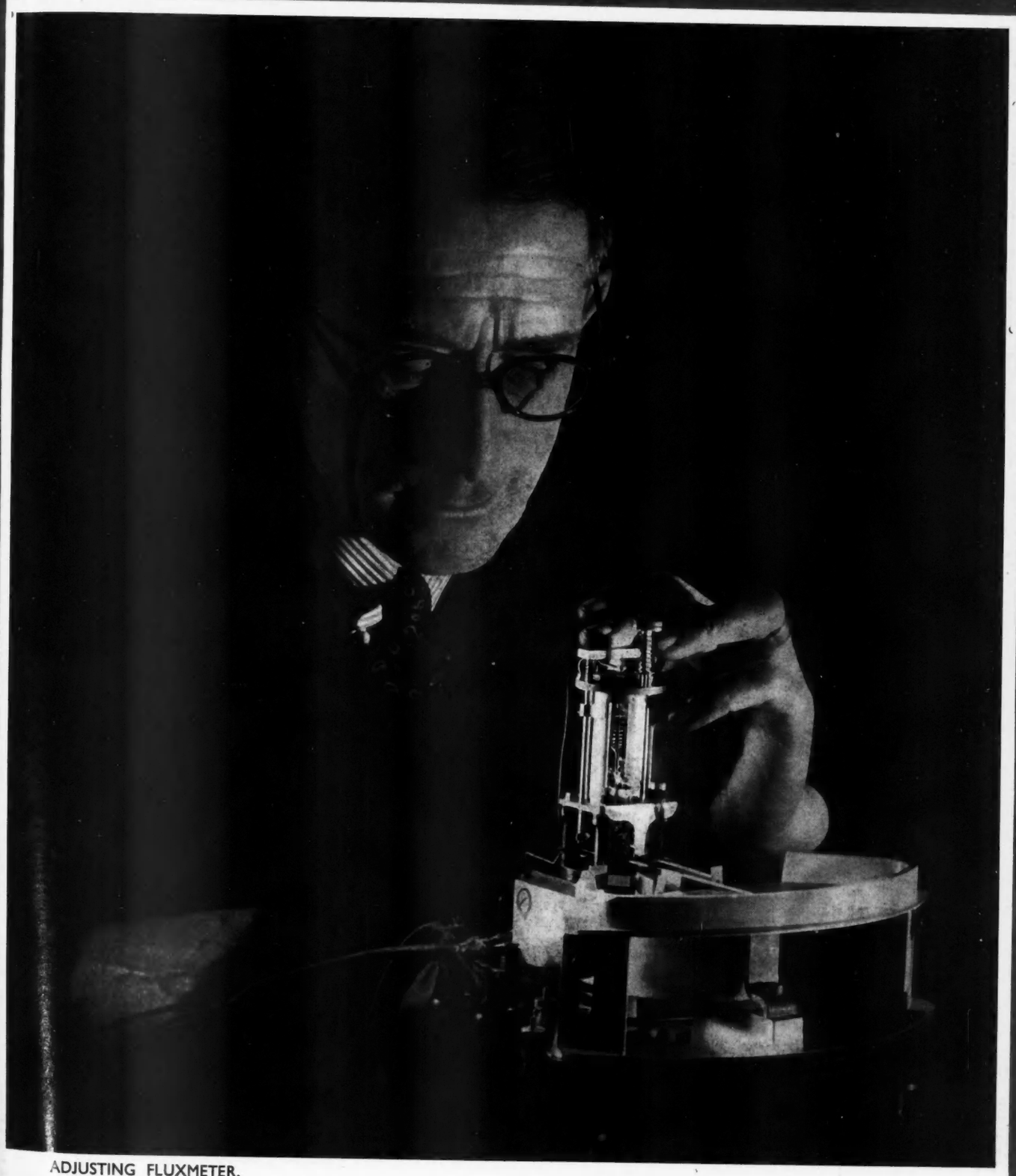

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PRESTRESSED-CONCRETE GRAIN SILO AT DUBLIN.

By T. J. S. Mallagh, M.A.I., M.I.C.E.

The adoption of prestressed-reinforced concrete for circular containers, in which the induced stresses are normally mainly tensile, offers many advantages. It is, therefore, somewhat surprising that this method of construction has not been more widely adopted for silos, which frequently have a circular cross-section. A few concrete silos on the Continent of Europe have been prestressed by the Magnel-Blaton system, and a few small fodder silos of prestressed concrete have been built in the British Isles, but, apart from the silo which is described in this article and is located in Southern Ireland, nothing appears to have been done to adopt prestressing for concrete silos. The silo in question is for native grain and has a capacity of 2,000 tons, forming part of a 7,500-ton grain-drying and storage project recently completed in Dublin for The Dublin North City Milling Company. The remainder of the storage capacity (5,500 tons) is in the form of a bulkhead store which, in itself, has certain interesting features. This article deals with the whole scheme but particular reference is made to the prestressed silo. The completed silo and working house, with the roof of the shed store showing above the railway embankment, are illustrated in Fig. 1, herewith.

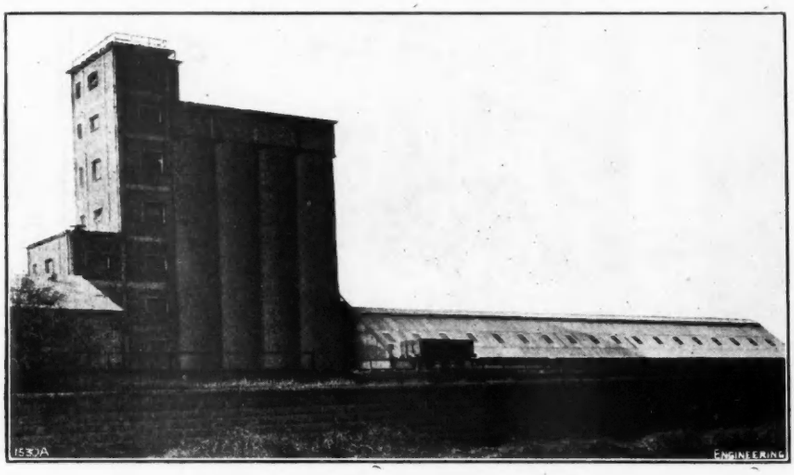


Fig. 1. Working-House, Silos and Shed Store.

Grain-Handling Facilities.

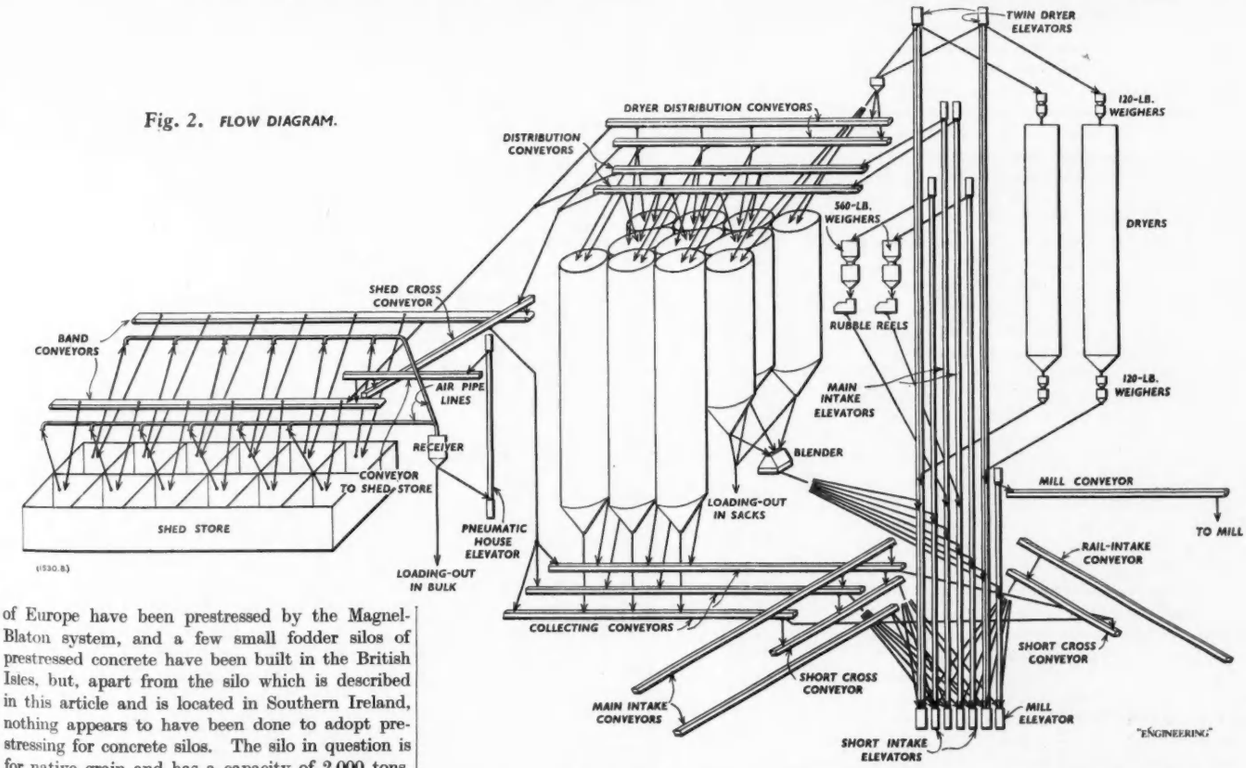
The grain is received at the milling company's premises either in bulk or in sacks by road or rail. Two intake hoppers for bulk delivery by lorries have been provided below ground, together with two sack hoppers in an intake platform which is about 3 ft. 6 in. high. A further sack hopper is available for the grain delivered by rail. Only two of these intake points can, however, be utilised at a time, as handling equipment has been provided for only two separate intake streams; the possible routes along which the grain can be directed are indicated in the flow diagram, Fig. 2, herewith. After intake, the grain is elevated to the fourth floor of the silo working house, whence it falls by gravity through the bulk weighers and rubble reels for preliminary cleaning. If they are not required, either the weighers or the rubble reels can be by-passed.

From the basement, the grain is again elevated, this time to the top of the working house, whence it is fed into the silo bins by the over-bin distribution conveyors. This grain will normally be "wet" or "green," being of native origin and having a moisture content of up to 30 per cent. In this condition, it can be left in the silo for only a few days at a time. The wet grain, when drawn off from the bins, is fed to twin elevators, before falling under gravity through the dryers. From below the dryers, the grain is again elevated on the other side of the twin elevators, and fed to the distribution conveyors over the bins, to be spouted through the roof of the shed store to the distribution conveyors within the shed.

For reclaiming the grain from the shed store, a pneumatic-suction plant has been installed, the grain being drawn into a receiver located in a small pneumatic house at the side of the silo. From the receiver, the grain is carried by a short elevator and conveyor back to the shed store where it can be fed to a cross-conveyor interconnecting the two halves of this building. From the shed cross-conveyor, the grain can be spouted to any one of the collecting conveyors in the silo basement, to be taken back to the silo working house, whence it can be loaded out to the mill by a short elevator and conveyor connecting the mill and silo. Alternatively, it can be returned to the top of the working house by any one of the long elevators for re-distribution elsewhere.

Apart from the main flow lines described above, examination of the flow diagram shows that several other handling operations are possible. In particular, the grain may be turned from one bin to another, from one shed compartment to another, from silo to shed, and so on. Turning the grain is normally carried out by means of the elevators and conveyors not otherwise employed in the intake, drying or loading out of other grain. The following main streams can flow simultaneously: (*a*) two intake streams at 20 tons per hour; (*b*) two drying streams at 4 tons per hour; and (*c*) one stream to

Fig. 2. FLOW DIAGRAM.



PRESTRESSED-CONCRETE GRAIN SILO AT DUBLIN.

Fig. 3. ARRANGEMENT OF REINFORCING WIRES.

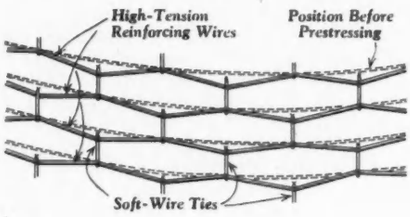
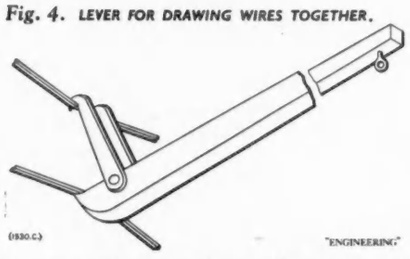


Fig. 4. LEVER FOR DRAWING WIRES TOGETHER.



the mill at 15 tons per hour. Alternatively, one of the intake or drying streams may be replaced by a turning stream in the silo, or by a stream from the shed to the silo, the mill then being fed directly from the silo. The turning of grain in the shed can be carried out independently, leaving the intake, drying and loading out to the mill to be dealt with solely by the plant in the silo.

Prestressed-Concrete Silo.

Some four years ago, the consulting engineers for the Milling Company's project, Joseph Mallagh and Son, recognised the fact that the cost of constructing silo storage in Southern Ireland was extraordinarily high compared with costs ruling prior to 1939. An analysis of several tenders disclosed the fact that this was due primarily to the increased costs of shuttering, the price of reinforcing steel being a contributory factor, and the increased cost of the concrete itself being of secondary importance. This appeared to indicate that economy could be secured by the use of pre-cast units, probably in conjunction with some method of prestressing. The prestressing of circular containers obviously required a form of construction with the reinforcing elements on the outside of the main concrete, to be covered later with gunite or other pneumatically-applied mortar. As such, the use of gunite was considered to be an advantage; owing to the difficulty of preserving proper cover over the reinforcing steel of tall circular silos, and the even greater difficulties encountered in the cases of square or hexagonal bins with steel in both faces of the walls, it has been found that, after a life of 25 years or less, many silos had to be completely re-faced with gunite. The correct cover over the reinforcement could be guaranteed and, furthermore, gunite proved to be a denser and less permeable material than the original concrete. There is, therefore, everything to be gained by the use of a gunite cover in the first instance, when it can be applied more cheaply than at a later date.

For constructional work in Southern Ireland, it was considered that any method of field prestressing that was adopted had to be capable of being undertaken by relatively unskilled labour, and that elaborate equipment should not be required. This obviously ruled out such methods as that in which a machine travelled round the container, winding on the prestressing cable in the form of a helice. Furthermore, this method is not applicable to grain silos in which the bins are nested together. On the other hand, pulling the wires in a longi-

Fig. 5. LONGITUDINAL SECTION.

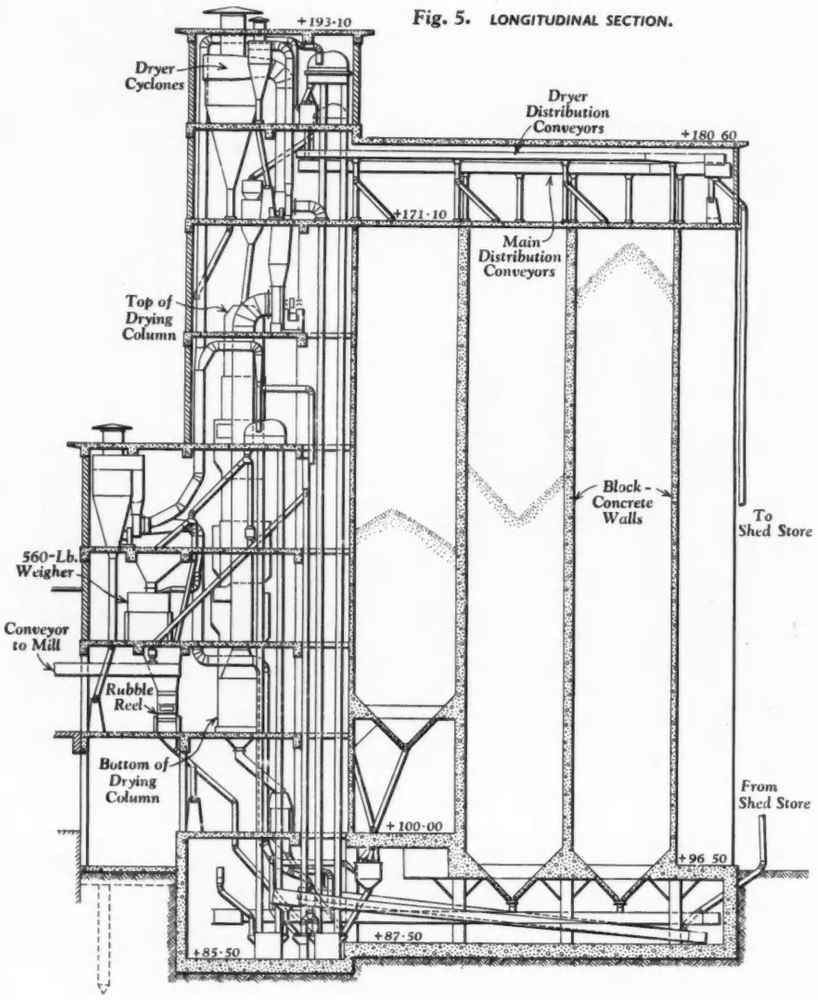
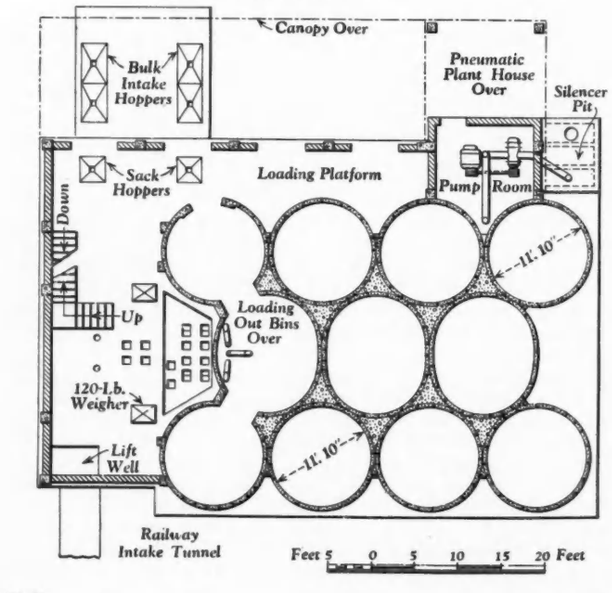


Fig. 6. GROUND FLOOR PLAN.



PRESTRESSED-CONCRETE GRAIN SILO AT DUBLIN.

(*For Description see Page* 577.)

FIG. 7. CONSTRUCTION OF FOUNDATIONS.

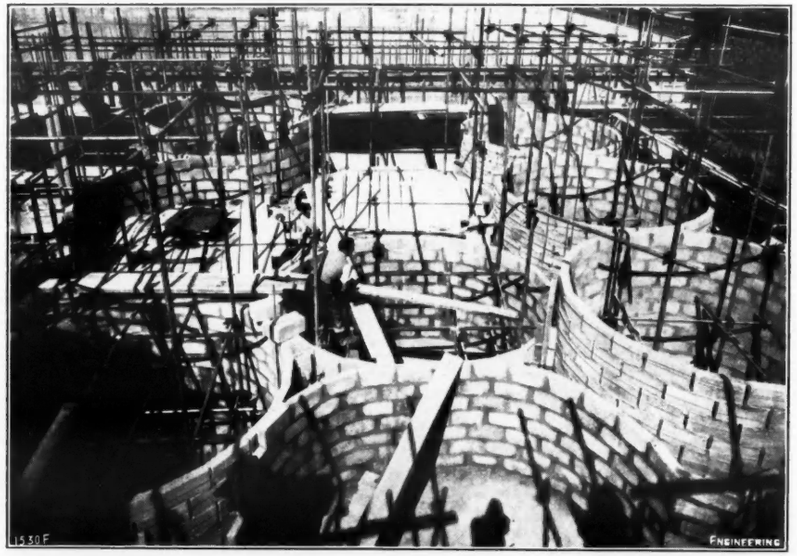


FIG. 8. CONSTRUCTION OF BINS.

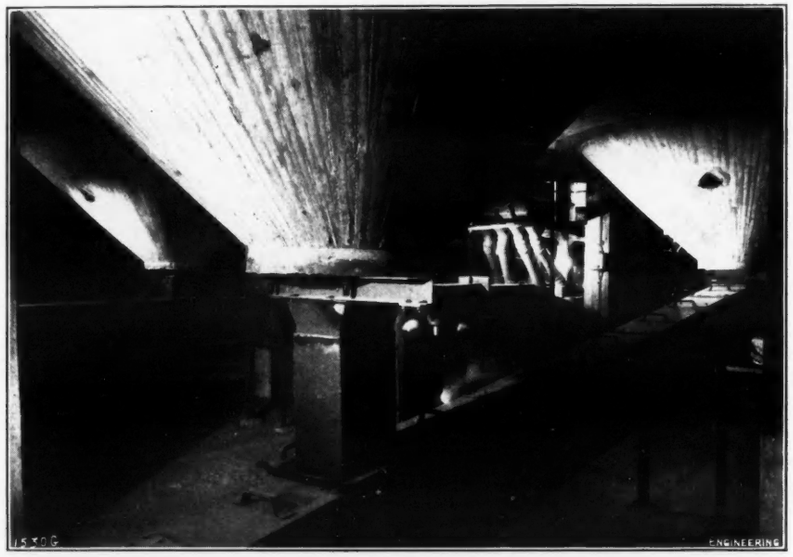


FIG. 9. HOPPERS AND COLLECTING CONVEYORS IN BASEMENT.

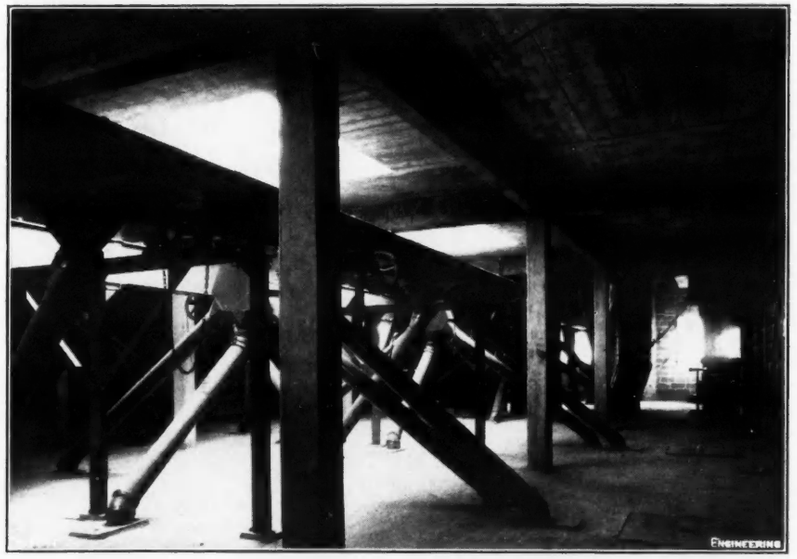


FIG. 10. DISTRIBUTION CONVEYORS AND FEED PIPES ABOVE BINS.

(*To face page* 578.)

PRESTRESSED-CONCRETE GRAIN SILO AT DUBLIN.

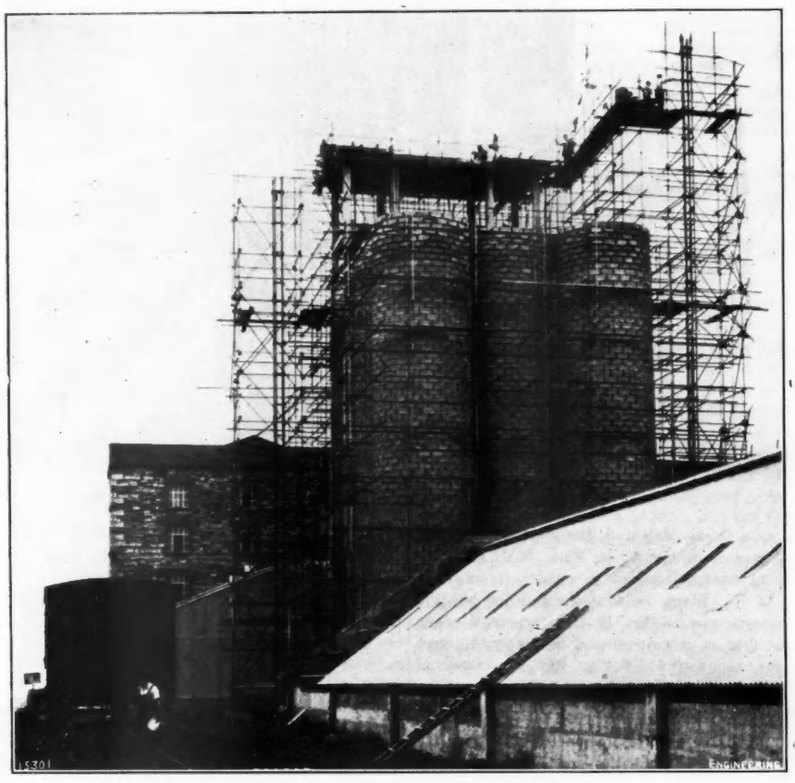


FIG. 11. SILO BINS NEARING COMPLETION.

Fig. 12. LAYOUT OF SHED STORE.

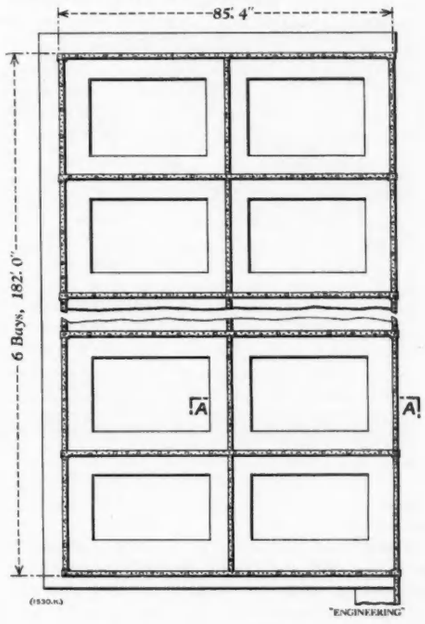
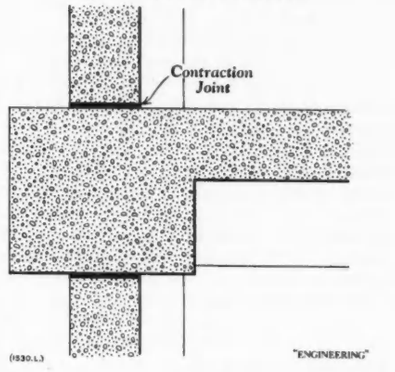


Fig. 13. DETAIL OF PILASTER.



tudinal direction suffers from the disadvantage that, in the case of circular containers, the loss of prestress due to friction is appreciable and the provision of anchorages difficult.

The method considered most promising depended on the principle that a small force applied perpendicularly to the longitudinal direction of a securely-anchored wire would create an appreciable increase in the stress in the wire. Several applications of this were worked out on paper and the best of these was tried out on a small experimental silo, until eventually the method used for the milling company's silo was evolved. This method is shown in Figs. 3 and 4. A lever is used to draw the circumferential wires together at staggered points and these wires are held in their deflected or stressed positions by soft-wire ties, the twist on the tie being made with a simple tool somewhat similar to an Archimedian screw-driver. The tie is of double hairpin form, and when made in 14-gauge wire, will take a load of 500 lb. The twisting action work-hardens the soft wire and thereby eliminates the tendency to untwist. This method is basically simple, no elaborate tools or plant being required and it can be carried out from normal scaffolding. It can be undertaken by relatively unskilled labour although a certain amount of "know how" is necessary. The ratio of force in the circumferential wires to the force in the wire ties is proportional to the sine of the angle of deflection; that is, it depends on the magnitude of the deflection of the circumferential wires on prestressing. If the circumferential wires are initially anchored too slackly, the deflection on prestressing proves to be more than is permissible and the force in the tie is greater than can be tolerated.

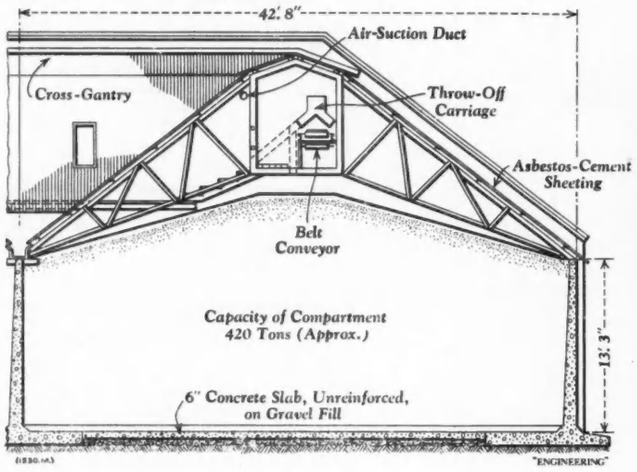
The prestress can, however, be measured at various positions just prior to applying the gunite, and any faults rectified. The measurement of the prestress does not have to be made at very close intervals as the net of circumferential wires and ties tends to adjust itself into a state of equilibrium, the over-stressed wires losing stress to those which are under-stressed. The degree of prestress is determined by the load which the end of the stressing lever will sustain. Friction between the wires and the concrete modifies this load, but consideration of the action of the stressing lever shows that there is a component of the force which tends to pull the wires away from the concrete, thus reducing the friction. The amount of friction involved can be computed fairly accurately by measuring the difference between the force required to deflect the wire slightly from its prestressed position and the force required to prevent the reverse movement. During actual prestressing, the operator deflects the circumferential wires slightly more than the deflection at which they are to be ultimately held by the ties. A proof stress is therefore automatically applied to the wires.

At the time the first experimental work was carried out, high-tensile wire could not be obtained in sufficient quantities in Southern Ireland and a work-hardened (twisted) wire of No. 5 gauge was used. Later, a high-tensile galvanised fencing wire became available. That the wire was galvanised was an added attraction as it formed a further safeguard against corrosion. For the method adopted, the bond strength is of no significance and any reduction in this respect due to galvanising is therefore unimportant. A galvanised wire is also used for the soft-wire ties, again with the object of reducing corrosion. However, in the case of the wire ties corrosion would not be very serious. It will be appreciated that once the silo is gunited, the ties could all be cut without affecting the prestress, although the vertical wire ties help to distribute the shrinkage stresses in the gunite.

For the first experimental silo, special curved blocks were used, but an investigation of the costs indicated that the use of special blocks would not be economical for a silo of less than about 10,000 tons storage capacity. The use of ordinary 18 in. by 9 in. by 4½ in. building blocks was therefore investigated, and it was found that, for a bin diameter of about 12 ft. or more, the angular irregularities left on the inside of the blocks after pointing were not sufficiently pronounced to be objectionable. On the outside, the only objection to the irregularities caused by the use of straight blocks was that a greater average thickness of gunite was necessary to obtain a uniform finish. For the Milling Company's silo, a high-grade concrete was used for the blocks, but as the stresses in a 4½-in. thickness of block were so low, it was doubtful if this was really necessary, always providing that the blocks were well matured. The blockwork was laid in accordance with conventional practice, using a Portland-cement mortar. The bins of the silo were 11 ft. 9 in. in diameter and 74 ft. high, and two 10-gauge circumferential wires were used on each 9-in. course of blockwork (except for the upper 10 ft. of the bins, where a single wire was used). The designed prestress in the wires was 112,000 lb. per square inch, which resulted in a compressive strength of 160 lb. per square inch on the mortar joints, assuming that only 2 in. of the joints were fully bedded. The soft-wire ties were

PRESTRESSED-CONCRETE GRAIN SILO AT DUBLIN.

Fig. 14. SECTION A-A (FIG. 12.).



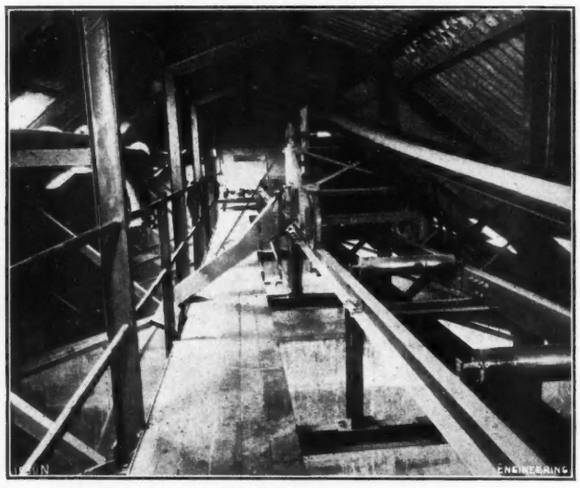


FIG. 15. DISTRIBUTION ARRANGEMENTS IN SHED STORE.

placed at 9-in. centres and staggered to suit the blockwork.

Two alternative designs for the silo were prepared by the consulting engineers, one for hexagonal bins of orthodox reinforced concrete and the other for circular prestressed bins. Tenders were invited for both designs and the tender for the prestressed bins proved to be more than 25 per cent. below that for the hexagonal bins. The former was therefore accepted. For the prestressed bins, 29 cwt. of high-tensile wire at a total cost of 253*l.* was used and 8 cwt. of soft wire for the ties at a cost of 41*l.*; the cost of fixing the wire and prestressing was 841*l.*, giving a total of 1,135*l.* or 31*l.* 12*s.* per cwt. The hexagonal bins would have required 460 cwt. of mild-steel reinforcement at a cost of 4*l.* per cwt., making a total of 1,840*l.* The rate of progress achieved during construction of the prestressed bins, while not spectacular, proved to be very satisfactory. The average progress on the eleven bins, which were erected concurrently, was six feet a week with a maximum of 11 ft. 3 in. in one week.

SILO FOUNDATIONS.

Piling the foundations would have been cheaper than the adopted solution of constructing a raft at the level of the boulder clay which had been found about 14 ft. below ground level, but the extra cost was offset by the saving due to the lowering of the bin-outlet levels, and the consequent reduction in the height of the structure. From the general arrangement of the silo, illustrated in Figs. 5 and 6, on page 578, it will be seen that the bins are carried on a heavy entablature slab at about ground level, with the discharge hoppers and the collecting conveyors housed in the basement. (The foundations were constructed for hexagonal bins; but for circular bins, and to make the best use of the layout, the centre bins had to be slightly elongated on one axis, as can be seen in Fig. 6.) These hoppers were formed in reinforced concrete, which was found to be cheaper than fabrication in steel. In the case of the three bins nearest the working house, the discharge hoppers were constructed about 18 ft. above the level of the hoppers of the other bins, as can be seen in Fig. 5. This was done in order that loading-out in sacks could be undertaken from these bins or, alternatively, so that wet grain could be spouted directly to the dryer elevators, thus eliminating the running of the conveyors for drying purposes.

The silo working house is of orthodox reinforced-concrete construction, with concrete-block panel walls. The arrangement of the basement foundations, entablature slab and discharge hoppers can be followed from Fig. 7, on Plate XXXII, while Fig. 8 illustrates the bins in course of construction. In Fig. 9 can be seen the finished hoppers and collecting conveyors in the basement, while the distribution conveyors and feed spouts above the bins are shown in Fig. 10. The external appearance of the silo and working house can be seen in Fig. 1 and Fig. 11, on page 579, shows the completed bins prior to guniting.

SILO EQUIPMENT.

All of the equipment in the silo, with the exception of the weighers and the rubble reels, was made and supplied by MIAG Mühlenbau und Industrie G.m.b.H., Brunswick, Germany, who also supplied the equipment required in connection with the shed store. As can be seen from Fig. 2, 13 conveyors and seven elevators (including two twin elevators) have been provided for mechanical handling within the silo. All the conveyors are of the trough type operating on the *en-masse* principle, in which a chain, with flights attached, is pulled through the grain so producing a movement of the whole mass of grain in the conveyor casing. A chain speed of about 65 ft. per minute was adopted.

The main machinery in the working house comprises the driers and their ancillary equipment. The driers are of the combined radiator and hot-air type having a capacity of four tons per hour. This type of drier consists essentially of a vertical drying column about 50 ft. high, containing hot-water radiators and inverted V-shaped air ducts (the bottom of the V's being open), together with a vertical air trunk with connections to the drying column. When operating, the drying column is kept full of grain by a valve, or gate, which is located at the bottom of the drier and controlled by a hopper at the top. At the top of the drying column, the grain first passes over hot-water radiator grilles or "sweating radiators" and air, which enters the column in the lower section, is drawn off into the vertical trunking. The temperature of the grain passing the radiator surfaces is above that of the air stream, although the latter will be appreciably above that of the surrounding air. With the grain temperature above the air temperature, the moisture will evaporate, provided that the humidity of the air is below that of the relative equilibrium humidity of the grain, which is virtually constant for any particular grain moisture content. As the air-stream temperature will be above that of the surrounding temperature, the air-stream humidity will be low, and drying of the grain will therefore occur. The sweating action of the radiators is attributed to the fact that, if the grain is being cooled by the air stream (which occurs when the radiators raise the temperature of the grain above that of the air stream) there will be a falling temperature from the centre to the exterior of each grain, and hence the water is sweated out from the centre.

After passing through the sweating radiators, the grain reaches the first hot air section. Air enters the drying column through heat exchangers mounted on the side of the casing and is drawn off into the vertical trunking. In this section, the air temperature is above that of the grain and it imparts some heat to the grain, but the main purpose of the hot air is to absorb and carry away moisture. The inlet air, being at a high temperature, will have a low humidity and, therefore, will absorb an appreciable quantity of moisture without the humidity of the air at exit from the section rising above that of the relative equilibrium humidity of the grain. If this occurred, moisture would be deposited on the grain near the air exit. After leaving the first hot air section, the grain passes through a second radiator section as well as a second hot air section, where the drying action is similar to that described above. Finally, the grain passes through a cooling section, air entering from the atmosphere at one side of the casing, and being drawn off into the vertical trunking on the opposite side. The suction in the trunking is created by a 20-in. multi-vane centrifugal fan running at 900 r.p.m. and exhausting through a 65-in. cyclone dust separator. The drier cyclones, in common with all cyclones in the silo, are fitted with motor-driven automatic sluice valves for discharging the dust. The heads of all the elevators, the bulk weighers, the transfer hoppers, as well as the rubble reels, are aspirated by a 30-in. fan exhausting through a 52-in. cyclone separator. A further 21-in. fan and a 30-in. cyclone are used for venting the bins.

The bulk weighers were supplied by W. and T. Avery, Limited, Soho Foundry, Birmingham, accommodation being made available for two 560-lb. and four 120-lb. models. The two 560-lb. weighers are for intake weighing and the 120-lb. models for installation before and after each drier. So far, only one 560-lb. and two 120-lb. weighers have been installed.

SHED STORE.

The shed store is unusual; firstly in that it is sub-divided, as shown in the plan in Fig. 12, page 579, into 12 compartments, each holding about

460 tons, and, secondly, in the method employed for reclaiming the grain. The sub-division of the store, in conjunction with the mechanical handling equipment installed, allows grain to be turned from one compartment to another, an operation which is not possible with the more usual type of un-divided grain shed store. The walls were designed as cantilever retaining walls but, as shown in Fig. 13, on page 579, continuity was deliberately avoided at the corners. The cross-division walls were constructed first, pilasters being formed at each end to create an architectural feature in the external walls, with expansion (or, more correctly, contraction) joints at each side of the pilasters. As the cross-division walls were cast in lifts extending for the full width of 85 ft. of the shed, a plane of weakness was deliberately formed in the centre where the "waist" effect of the valley would tend to cause a concentration of contraction stresses. The cracks that formed at these planes were covered by the ends of the longitudinal division walls, which were butt jointed against the cross walls. By these methods, cracks (or the opening of the joints) only occurred at predetermined positions where they were neither detrimental nor disfiguring.

The site of the shed was such that the compartments could be arranged in pairs most conveniently. The band conveyors used for filling, and the suction-pipe line used for emptying the compartments, had, therefore, to be duplicated, but this arrangement avoided the excessive length of conveyor and pipeline which would have been required had the compartments been placed in a single row. The two halves of the shed are connected by a gantry built into the roof at one end, this gantry housing the cross conveyor which connects the main band conveyors. As can be seen from Fig. 14, opposite, the roof trusses embody a portal frame to accommodate both the band conveyors and a walkway. The band conveyors used for filling the shed store are each fitted with a travelling throw-off carriage, the arrangement being illustrated in Fig. 15, opposite, from which it can be seen that there are two alternative spout positions on each side of the walkways on both sides of the conveyor.

Reclaiming the grain is carried out by means of a small pneumatic-suction plant of the type used for discharging vessels at port installations. A 4½-in. diameter pipe line runs along each shed gantry with a branch leading to each compartment, those not in use being sealed by removable airtight caps. To discharge grain, a connection is made from an appropriate branch by means of combined lengths of flexible and rigid pipeline terminating in a nozzle with adjustable air control. The pipelines carry the grain to a receiver where, by reason of its relatively large cross section and consequent reduction in air velocity, the grain separates from the air stream and falls to the bottom of the receiver, whence it is removed through a motor-driven rotary spider air-seal valve. After the receiver, the air passes through a hand-tapped air filter, of the cloth-sock type, and then to a rotary pump which exhausts into a silencer pit. The dust extracted by the filter is discharged through a valve similar to that on the receiver, both valves being driven from a common motor. The pneumatic plant is housed at the side of the silo, the pump with its motor at ground level and the receiver and filter being so arranged that grain from the receiver can be spouted into lorries standing below the first floor.

The contractors for all the building and civil engineering work were John Paul and Company, Limited, Donnybrook, Dublin.

GERMAN PRODUCTIVITY TEAM VISITS SHEFFIELD.—A productivity team from Germany, which has become a vigorous competitor in steel and engineering, is to visit Sheffield. The team will be accompanied by two German-speaking members of the staff of the British Iron and Steel Federation, and will tour the Steel, Peech & Tozer Branch of the United Steel Companies, Ltd.

LITERATURE.

Cornish Pumping Engines and Rotative Beam Engines: An Illustrated Survey.

Cornish Engines Preservation Society, Trevaunance Road, St. Agnes, Cornwall. [Price, to members of the Cornish Engines Preservation Society, 5s., to non-members, 15s.]

THIS, the third of the Surveys of the remaining Cornish engines in Cornwall, issued by the Cornish Engines Preservation Society, is the first to be illustrated. The general plan of the previous Surveys (first edition 1943; second edition, revised, 1950), has been followed in the present publication, but the text has been revised where necessary, to bring the Survey up to date. The revision has resulted in one notable omission: New Cook's 90-in. engine, at South Crofty Mine, Camborne, which previous Surveys listed as suitable for preservation, was so badly damaged by an accidental breakage of the beam in 1950 that repairs were impracticable, and the engine has been broken up for scrap. One other engine, Wheal Busy 85-in., at Chacewater, has also disappeared from the list, having been broken up in 1952, and the future of one or two of the few engines which remain is doubtful. The Survey records a marked improvement in the condition of one engine. Rostowrack 22-in. single-acting rotative engine from St. Austell, listed in 1943 and 1950 as still at work (though its future in the latter year seemed questionable), is now preserved in Messrs. Holman Brothers' museum at Camborne, where it has been arranged to run on compressed air. Nevertheless, a comparison of the present and the previous Surveys shows that more has been lost than gained, and emphasises the urgency of the efforts being made by the Cornish Engines Preservation Society to safeguard the future of the remaining engines.

In compiling the present Survey, the Society have done much more than present a mere list of engines. The essential feature of a Cornish engine is the steam cycle which is peculiar to it, and the Survey commences with a description of this cycle. To the description is appended a short glossary of the terms used by the Cornish engine drivers to describe some of the parts of the engine. It might be added that where a Cornish engine still survives in the county of its origin, these old terms survive too; it is still possible to hear in a Cornish engine house of the engine making its "indoor" or "outdoor" stroke, to see the massive "bob," and to watch the "scoggans" and "scoggan catches" in operation, to quote only a few of the specialised terms which have developed with the engine.

All the remaining engines in Cornwall are described in the Survey, and each description is accompanied by photographic illustrations. There are 30 illustrations altogether, and the photographs have been well chosen. There were detailed variations in the construction of Cornish engines, which is only to be expected, since many different designers were involved, but on the whole they adhered to a general plan. The illustrations have been chosen with these facts in view, and from them it is possible, not only to see some of the individual features introduced by particular designers, but also to obtain a general overall impression of the Cornish engine as it once appeared in so many parts of the county. There is, for example, an exterior view of Robinson's 80-in. engine at South Crofty Mine, which shows a typical three-storey stone-built engine house, with its two-thirds stone and one-third brick boiler chimney stack built on to the corner. The illustration of the valve gear of the Carpalla 40-in. engine at St. Austell typifies the normal practice of the old firm of Harvey and Company, of Hayle, and the picture of the little "whim" or winding engine at Levant Mine, near Land's End, shows the remarkable cliff-edge position which was by no means uncommon in Cornwall. Valve gears of various types, "nozzles" or valves, "bobs" or beams, winding engine reversing gear, different forms of parallel motion, condensers and air pumps are all illustrated.

The literature dealing with Cornish engines is fairly extensive, but it is scattered, and some of the best sources are rare, and difficult to obtain. Good photographic illustrations are even more difficult of access, many of them being in private possession. The present Survey brings together authentic technical data, and a set of excellent photographs from various sources, and the result is a compact booklet which gives a true picture of the Cornish engine in Cornwall to-day. The Cornish engine as a prime mover is almost extinct, but it was, in its day, the most efficient machine for its purpose which had been devised, and if it cannot now hold its own as a source of power, there is still much to be learned from it. It is the self-imposed task of the Cornish Engines Preservation Society to see that the engine is not forgotten, and the present Survey is a step in the right direction. The publication of the Survey is well timed, for it indicates that, although the past efforts of the Society have been valuable, much remains to be done.

Method for Determining the Resolving Power of Photographic Lenses.

By FRANCIS E. WASHER and IRVINE C. GARDNER. United States National Bureau of Standards Circular No. 533. The Superintendent of Documents, U.S. Government Printing Office, Washington, 25 D.C., U.S.A. [Price 1 dol.]

THIS circular supersedes N.B.S. Circular 428 (1940) and provides two new lens resolution charts, additional copies of which can be obtained separately. The first chart is a high-contrast one consisting of black lines on a white background; the second is of low contrast, obtained by printing the lines with grey ink on grey paper, the approximate contrast between the two sets of lines being 1·4 and 0·20, respectively. The pattern on both is identical, consisting of 24 groups of three lines each arranged vertically and horizontally. The six pairs of left-hand vertical and top horizontal three-line groups are identical and numbered diagonally 12, 17, 24, 34, 48 and 68 while the six pairs of bottom horizontal and right-hand vertical three-line groups are numbered 14, 20, 28, 40, 56 and 80. These numbers represent the number of lines per millimetre on the negative when these charts are photographed at a 25 × reduction, obtained by placing the target 26 focal lengths in front of the lens to be tested. The ratio of the line spacings between consecutive groups in opposite patterns thus approximates closely to $\sqrt[4]{2}$. The lines themselves are sufficiently long to permit the negative images at 25 × reduction to be scanned in a microdensitometer without loss of sensitivity. Directions are given for extending the range to cover resolving powers of the less-often required values between 3·5 and 14 lines per millimetre. Detailed instructions for carrying out the tests include arrangement and illumination of the charts, supporting and focusing of the camera, and photographic technique. Following this is a thorough discussion of the interpretation of the results illustrated by data obtained with actual lenses. Occupying the centre of the chart pattern are two concentric circles of such a size that their radii subtend angles of 1 and 2 minutes when viewed at a distance of 35 ft. The use of these to test prismatic power in goggles and sunglasses and to find the limit of resolution of telescopes and binoculars is described. By following the clear instructions contained in this circular any photographer, amateur or professional, can, with equipment normally at his disposal, obtain a numerical measurement of the resolving power of his lenses.

VARIABLE-PITCH MARINE PROPELLER.

A VARIABLE-PITCH propeller offers as many advantages to the mariner as it does to the airman. With this consideration in mind, Rotol, Limited, Cheltenham-road, Gloucester, have developed, during the past few years, a marine version of their aircraft propeller. The first trial model was designed for a high-speed launch and was driven by an electric motor with a shaft running down the "A" bracket and an 8,000-to-1 right-angle reduction gear at the boss. This arrangement proved the efficiency of the propeller, but it was too expensive for general use. A design was then put in hand with a hydraulically-operated ram to move the blades, the oil supply being fed through the propeller shaft. The development models gave good results, the response being quick and sure. The system was modified from the lever control used at first, so as to be suitable for use with a constant-speed control operated directly from the engine.

Fig. 1 shows one of the earlier installations—that in H.M.T. Capable. This was a large harbour and ocean-going tug with a displacement of 1,200 tons and driven by two triple-expansion steam-engines, each developing 1,500 h.p. at 140 r.p.m. Testing was begun early in 1948 and the propellers have since been in constant service. Each propeller is 10 ft. 6 in. in diameter, with a boss 3 ft. 3½ in. in diameter. A longitudinal section of this propeller is given in Fig. 2. The blades have a pitch range of 110 deg., from 90 deg. ahead to 20 deg. astern. The 90-deg. ahead position is known as "feathered" and is used in the event of an engine failure, for it then offers no resistance to forward movement through the water and eliminates any tendency for the propeller to drive the engine. The tug had previously been fitted with fixed-pitch propellers and it was found that the bollard pull was increased from 27 tons to 36 tons by fitting the variable-pitch propellers. Another great advantage was that the tow could be taken up gradually, enabling better control to be maintained. Manœuvrability was also improved. By suitably setting the blade angle, a vessel can be held stationary in a tideway, and eased into position as required. This characteristic has been of advantage in a Vosper fire-float, in which the reaction of the water-jets can be balanced by adjusting the blade angle. It also enables the total available engine power to be divided between the propulsion and pump requirements in any desired proportion.

Variable-pitch propellers have been fitted to high-speed launches with good results, though it has been found that the top speed, i.e., the designed speed of the fixed-pitch propellers, is reduced by between 1 and 1½ knots, owing to the larger ratio of hub to blade diameter necessitated by the blade rest fairings and operating gear, and also to the fact that this larger hub is inclined to the direction of flow of water. Endeavours are being made to improve the hydrodynamics of these propellers and so reduce the drop in top speed. At cruising speeds a marked improvement has been observed. The trial results of two 110-ft. Fairmile Class-D boats, one fitted with fixed-pitch and the other with variable-pitch propellers, show an increase in operating range of 85·3 per cent. at 15 knots and of 4·75 per cent. at 30 knots.

These boats are fitted with four Packard 1,250-h.p. engines and have a designed top speed of 32 knots. Towing tests have shown an increase in pull of 70 per cent. When these boats are running at reduced power, with one or more engines stopped, the feathering of the stopped propellers reduces the drag, with a corresponding improvement in fuel consumption and increase of range. High-speed starts can be made by having the engines running with the blades at zero pitch and then increasing the pitch. Fig. 3 shows a sectioned launch propeller, having a diameter of 36 in.

Fig. 5 is a diagram of the hydraulic system. Oil is supplied by the operating pump, which is driven from the propeller shaft. An auxiliary pump is also fitted, driven independently by an electric motor for use when the propeller shaft is stationary. To alter the pitch of the blades the control rod is moved, either directly or through a servo-system.

VARIABLE-PITCH MARINE PROPELLER.

ROTOL LTD., GLOUCESTER.

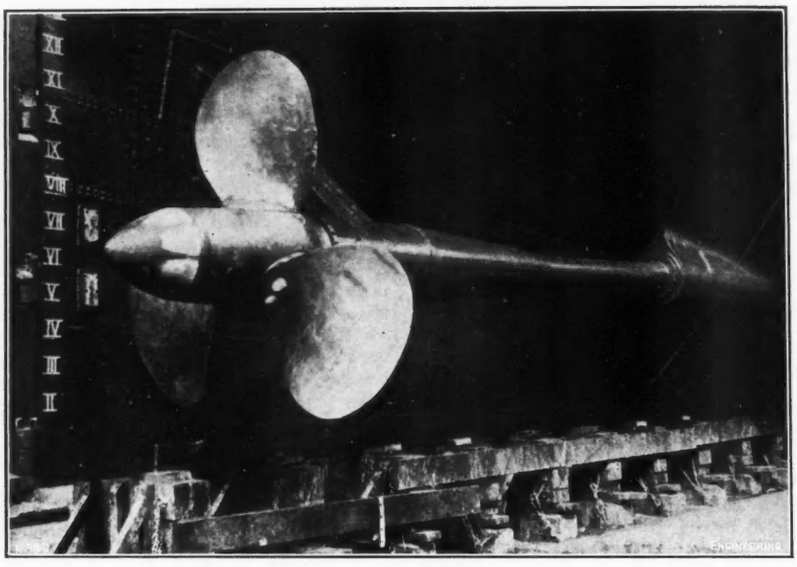
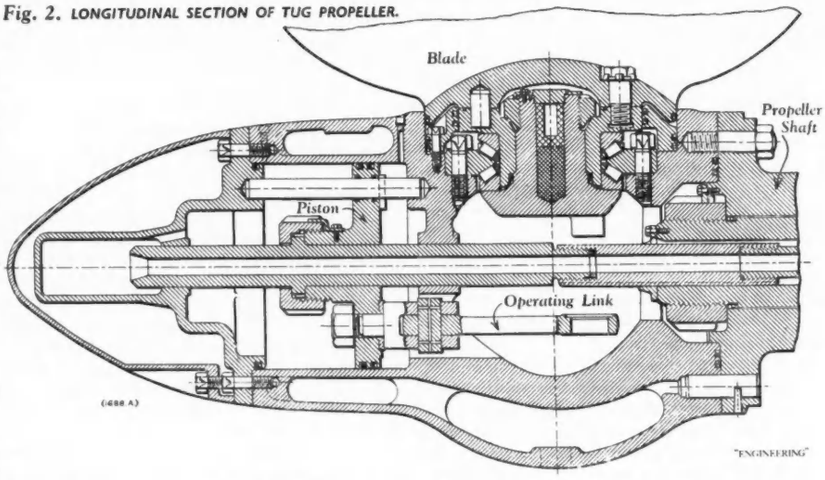


FIG. 1. PROPELLER OF H.M.T. "CAPABLE," 10 FT. 6 IN. IN DIAMETER.

Fig. 2. LONGITUDINAL SECTION OF TUG PROPELLER.



This rotates the upper bevel wheel of a differential gear, and, since the lower bevel is held stationary by the control sleeve on the shaft, the spider of the differential rotates and with it the cam which is on the same shaft. This cam then causes the selector valve to move, admitting oil to one side of the main piston in the propeller boss and connecting the other side to the return line. It will be seen, in Fig. 5, that the piston is mounted on a long inner tube, and that the other end of this tube is coupled to the control sleeve. Oil to the left-hand side of the piston (Fig. 5) passes into the inner tube through the radial holes shown. Thus, the piston is moved and the blades, which are linked to the piston, are rotated. At the same time, the inner tube is drawn along and carries with it the control sleeve. As the control rod is now fixed in its new position, movement of the control sleeve will cause the spider, and therefore the cam, to rotate in the opposite direction to its previous motion, thereby restoring the selector-valve to its neutral position. The response is almost instantaneous and the movement is dead-beat. Any tendency for the blades to wander is immediately counteracted, by the selector-valve. A relief valve in the system balances the lines and safeguards against excessive pressures. The pitch of the blades is shown by a mechanical indicator operated by a wire attached to the control sleeve. The differential gear, selector valve and control sleeve are all part of the oil-transfer unit which feeds the oil to the inside of the propeller shaft. This unit is usually interposed in the shafting immediately after the reduction gearbox.

The operating sequence described above is the one favoured by many ship-masters, who like to have all the controls separately to hand. However, it requires a knowledge of the engine conditions; for those who prefer automatic regulation, a constant-speed unit can be incorporated. Such a unit is shown in Fig. 4. It is driven from the engine and consists of a governor unit of spring-loaded fly-weights. These actuate a selector valve, admitting oil to the servo system and causing the required pitch change. The governed speed setting can be altered by moving the single lever (Fig. 4), which changes the initial loading on the fly-weight spring. This gives a governed range from full power ahead down to a predetermined figure at which the fly-weights become inoperative, with automatic pitch adjustment throughout. Below this figure the selection is manually controlled, usually for manœuvring and astern speeds where such control is desirable. This system conforms closely to the standard aircraft technique.

Mechanical details of the actuating mechanism

VARIABLE-PITCH MARINE PROPELLER.

ROTOL LTD., GLOUCESTER.

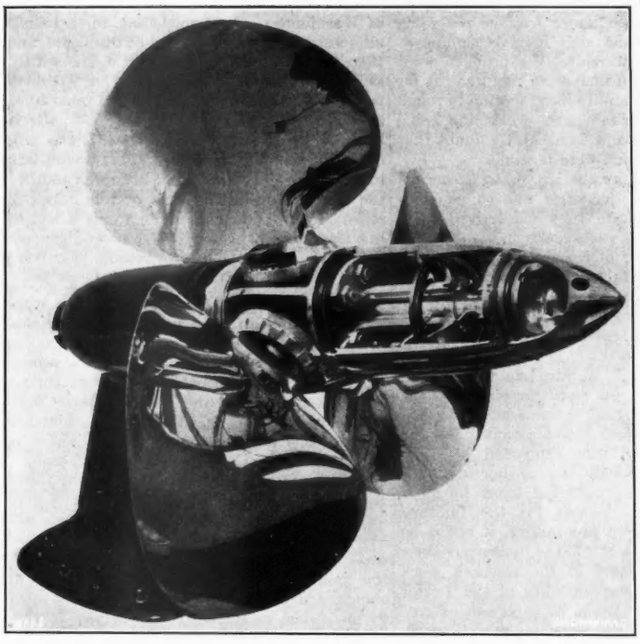


FIG. 3. HIGH-SPEED LAUNCH PROPELLER, 36 IN. IN DIAMETER.

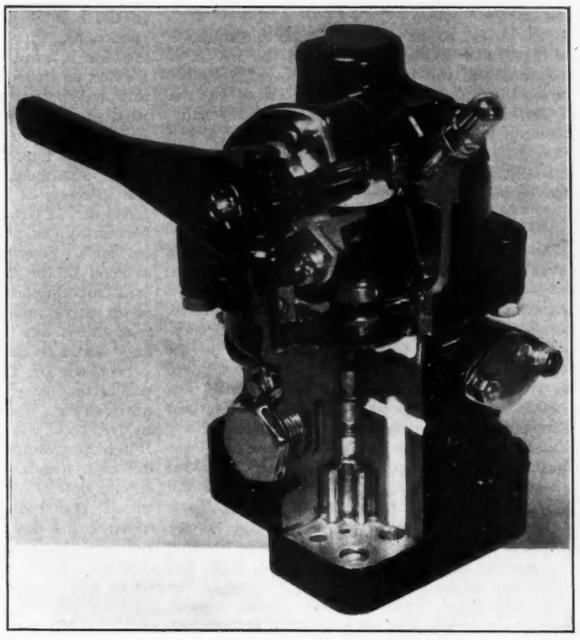
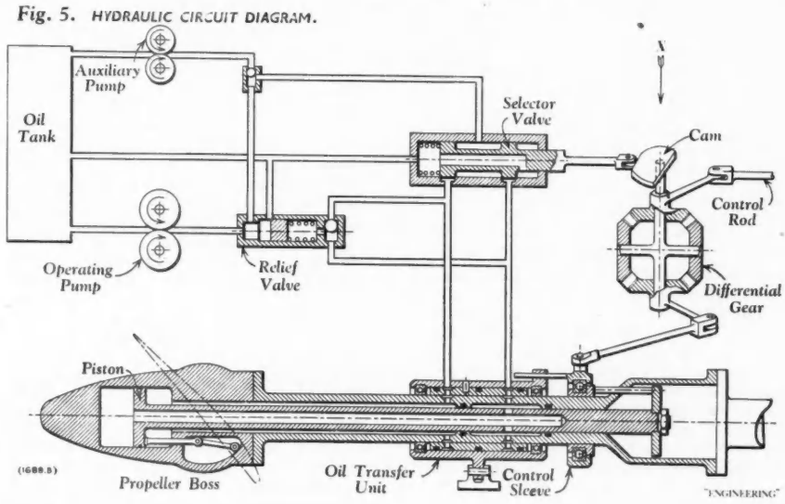


FIG. 4. CONSTANT-SPEED CONTROL UNIT.

Fig. 5. HYDRAULIC CIRCUIT DIAGRAM.



are shown in Fig. 2. The blades are mounted on a bearing spigot which turns on a two-row taper-roller bearing. This bearing can be preloaded by a nut on the top of the spigot. An eccentric pin on the spigot carries the link from the driving piston. Synthetic-rubber seals are used throughout and have proved trouble-free in service. Since the oil in the system is always at a higher pressure than the water outside, any leakage is outwards and is quickly detected by a fall in the level of the header tank. During five years operation in the Capable the leakage has been found to be negligible. The maximum oil pressure reached during high-speed operation with the launches was 650 lb. per square inch, but normal pressure is about 150 lb. per square inch. The pitch can be altered at a rate of 15 deg. per second, enabling a launch travelling at 33 knots to be stopped in 30 seconds. That the mechanism can withstand hard use was shown when the port propeller of the Capable fouled some mooring chains, severely damaging one blade. The only damage to the mechanism was the elongation of one bush. Blades can be removed without disturbing the rest of the gear simply by unbolting them from the spigots. A complete new propeller can be fitted to a launch in 45 minutes.

Variable-pitch propellers have been fitted to several different classes of vessel, all of which have shown improvement in performance. The smallest has been to a motor yacht of the Cadet class. These vessels are 12 ft. long and have a beam of 4 ft. 10 in.; they are driven by a petrol engine giving 15 h.p. at 3,000 r.p.m. In this case the pitch is mechanically controlled, and the propeller has a blade diameter of 8½ in. and a hub diameter of 2½ in. The Thames tug Trela is an example of a medium-size river craft fitted with the propellers, and here, as with the Capable, many advantages in towing and manœuvring have been found. More recently, these propellers have been fitted to a 275-ft. submarine, where, in addition to all the surface advantages, the engines can be run at the required rate for battery-charging while still leaving some freedom for manœuvring. On the surface, at half-speed, the charging rate can be doubled. Torpedo boats and air-sea rescue launches have also had variable-pitch propellers fitted, and the latest application is to the Royal Navy's Grey Goose, which is driven by two 6,000-h.p. Rolls-Royce gas-turbines. The use of variable-pitch propellers has provided a convenient means of going astern and the correct combination of pitch and speed can be obtained for every operating condition. No doubt there will be other applications as development proceeds.

BONDED FRICTION LININGS.

A DEVELOPMENT during the latter part of the 1939 war was the bonding of friction linings to the clutch plates of 35-ton tanks, with the result that the life of a clutch assembly was increased tenfold. This bonding process has recently been adopted by Thomas Broadbent and Sons, Limited, Huddersfield, in the manufacture of their centrifugal friction clutches. A bonded lining has many inherent advantages over the more usual riveted or set-screw method of attaching a lining to a shoe, as, in the first place, the complete absence of rivets or set-screws renders scoring of the friction surface quite impossible, while the lining itself may be worn down to paper thickness before its replacement is necessary.

The bonding is effected by spraying a coat of synthetic-resin bonding cement over the metal surface and also over that face of the lining which will be in contact. After heat-drying, in order to remove all traces of the solvent used in the bonding cement, the respective shoes and linings are assembled in pressure jigs which are then heated in an oven to a temperature of 180 to 200 deg. C. After heating at this temperature until the bonding cement is sufficiently roasted, the jigs are withdrawn, allowed to cool in air, and opened up for removing the shoes and attached linings

Tests on the efficiency of the bond obtained have been carried out on a Denison testing machine, and it was found that before the bond would give way, the lining material began to fail under the compressive load applied, which indicated that resistance to shear is far above what would be met with in practice and greater than that provided by the normal number of rivets used for attaching a lining.

THE INSTITUTION OF NAVAL ARCHITECTS' AUTUMN MEETING.

(*Continued from page 522.*)

THE second paper to be presented and discussed on September 16, and the fifth of the six in the programme of the Institution of Naval Architects during their Autumn Meeting in Holland, was that of Dr. F. H. Todd on "The Hydromechanics Research Programme of the Bureau of Ships, U.S. Navy." The chair was occupied by Sir Stanley V. Goodall, K.C.B., C.B.E. A summary of the paper is given below.

RESEARCH BY THE U.S. BUREAU OF SHIPS.

Dr. Todd's paper described the organisation of naval research in the United States; in particular, the scope and methods of administration of the programme of fundamental hydromechanics research of the Bureau of Ships. The author mentioned, however, in presenting an abstract of the paper, that the Research and Development Board (to which the paper made frequent reference) was to be disbanded and its place taken by an Assistant Secretary for Research, under the revised Navy Administration. The research programme was planned in association with the Office of Naval Research, the Society of Naval Architects and Marine Engineers, the American Towing Tank Conference, and various universities and laboratories, some of which had their own research organisations; for example, the S.N.A.M.E. had committees to deal with eight sub-sections of the main subject of hydrodynamics, these dealing, respectively, with current research projects in hydrodynamics, resistance and propulsion data, skin friction, parent forms for standard series, ship-wave relations, scale effects in self-propulsion tests, seaworthiness, and ship vibration. Similarly, the A.T.T.C. had six sub-divisions, dealing with geometrically similar models, steering, resistance and propulsion data, seaworthiness, skin friction, and propellers and propulsion. Having outlined the general organisation, Dr. Todd proceeded to describe some of the research work in progress at the David W. Taylor Model Basin and elsewhere. This included work on a single-screw model, designed to investigate propeller-excited ship vibration; and new studies of the behaviour of ships among waves, for which purpose a pneumatic wave-maker had been installed in the 140-ft. basin at Carderock. This generates waves by alternate increases and decreases of the air pressure in a dome above the water surface.

DISCUSSION.

Mr. V. G. Shepheard, C.B., Director of Naval Construction, in opening the discussion, said that he was particularly interested in the paper because it was his responsibility to plan the programme of ship-hydromechanics research for the British Admiralty. Unfortunately naval architects in Great Britain were not so generously provided with facilities for such work as were their fellows in America, nor could they afford to employ such large staffs. They had to concentrate, therefore, on those items of research which, in their opinion, would pay the best dividends in the types of warships that they were likely to build in the foreseeable future. That did not mean that all their researches were of an *ad hoc* nature, but rather that they had to select very carefully their items of basic research—not altogether a bad thing, as it ensured that the main objectives were kept constantly in mind, and undoubtedly provided the best return for a limited expenditure of both money and effort. The paper showed that the research programme was organised under eight main headings; that was a neat and concise division, but each item included a wide range of subjects. Which item held the greatest promise of worth-while improvement in the performance of ships of all types—merchant ships and warships alike? He would suggest researches in ship motion and seaworthiness, including a study of ship resistance and propulsion among waves. That was a subject about which surprisingly little was known, and he was pleased to see that the Bureau of Ships was instituting a comprehensive study of the problem. In the past, the emphasis had been on designing for the best ship-performance in smooth water, which was the normal towing tank condition; but the naval architect and the shipowner were more interested in the best performance under average sea-going conditions, which might well involve significant changes in form. In warships, the problem went farther, as there was an increasing requirement for improved performance and reduced motion in rough weather. In Great Britain also, work was being done on that problem, and he had little doubt that appreciable improvements were possible.

The plan mentioned by the author to encourage the interests of the universities was to be commended. In Great Britain, they had derived much benefit from that source, particularly in the theoretical fields. Overlapping of research effort must be avoided in the interests of timely results. Ship-tank superintendents had made some advance in co-operative and complementary research in the past and it was to be hoped their efforts on those lines would be maintained.

Professor Dr. Ir. W. P. A. van Lammeren, comparing the paper with his own, presented on the previous day, observed that the research described by Dr. Todd was of much broader scope than the Dutch programme and was supported by very different means. Although the author did not specify details of the astronomical figure he mentioned (1,500 million dollars) for the military research and development programme, it might be supposed that a fair part of it fell to hydromechanics research. Since that part of the research work being done under the responsibility of the Taylor Model Basin was comparable, to a certain extent, with that carried out in the European model basins, it would be interesting if the author could give an idea of the expenditure on hydromechanics. The paper showed that the hydromechanics research programme covered a great number of more fundamental subjects, each of which brought new problems. Owing to the limited funds available in the Netherlands, research there must be restricted to practical subjects which were less expensive. The results served the daily need to give a more and more perfected service to shipbuilders and shipowners. Apart from its review of organisation and a general picture of the research work being carried out, the paper gave numerous experimental data. He would like to comment on the author's remark that the many non-systematic model tests carried out in the past could not really help in the design of optimum ship forms. Professor van Lammeren did not agree on that point; a carefully built-up system of statistics for a number of ship types would enable the designer to find the best solution for any specific design condition. Further systematic series on parent lines might render more easy the judging of performance, and he was in favour of the suggestion to use the results of the new methodical series 60 as a basis for the correlation of research work throughout the world.

Professor E. V. Telfer, D.Sc., said that, early in the paper, Dr. Todd referred to the remarks of Mr. E. A. Speakman, when commenting on the facts that two-thirds of the United States scientists and engineers were engaged, and nearly 1,500 million dollars a year were spent, on military and defence research, which Mr. Speakman regarded as "startling, sobering and thought-provoking." It was, indeed, terrifying that a nation should, out of fear, have to go to such expenditure of effort, and he would like to think that neither aggression nor fear was the motivating force of research. He refused to believe that the prosperity of the United States could be maintained by only one-third of their scientists and engineers. That showed either that the better scientists and engineers were still out of the research field or that scientists and engineers did not matter at all, so far as the economy of a country was concerned. Dr. Todd thought that it was to the credit of the American Towing Tank Conference that in 1947 they adopted the Schoenherr friction line and also the roughness correction. Professor Telfer did not endorse that statement, but deplored that they dropped the Froude and went to the Schoenherr; he thought it impossible for any work that Professor Davidson could do in the Stevens Institute, based on Froude coefficients, to show any correlation with that at the Washington tank. If there was to be some co-ordination between the two bodies, Professor Davidson would have to find some other correlation which would put the Stevens Institute results on a par with those of Washington. He hoped that, in those matters, all questions of politics would be dismissed, and that there would be a real choice of a line which fully satisfied all the facts of the case. Dr. Todd referred to series 57 and the fact that he had some 40 organisations helping him to select the best pattern as a basis, it being found that series 57 was probably one of the worst of all forms. That was no criticism of Dr. Todd. It showed how little was known about the choice of optimum forms, and he hoped that in series 60 Dr. Todd would find not only a better form, but the reason why series 57 was so disappointing. If Dr. Todd could give that reason, that one point alone would justify the writing of the paper.

Professor G. Aertssen observed, with regard to the tank tests and the full-scale ship trials, that there was a correlation which was hardly influenced by the laminar flow existing over the entrance of the model. Dr. Todd mentioned different turbulence-stimulating devices and he (Professor Aertssen) had heard from him that the studs were used originally for this purpose by the Ship Division of the National Physical Laboratory. Full-scale trials had been undertaken on a Victory ship by the Centre Belge de Recherches Nouvelles. Models were run by the N.P.L. and the Taylor Model Basin in order to establish the correlation of the tank test and the measured-mile trial, and the reports showed that the model used at Teddington was fitted with a standard trip-wire 0·036 in. in diameter, attached to the model at station $9\frac{1}{2}$; whereas, in the case of the model used at Washington, turbulence was stimulated by means of studs. Comparison of the results would be interesting, though difficult to make. There seemed to be a concerted attack on the boundary-layer problem in different countries. He admired the work done on semi-full-scale in the case of the D. C. Endert, Jr. by Professor van Lammeren, but felt that, until Professor van Lammeren's ambitious project of towing a Victory ship was carried out successfully, velocity measurements in the boundary layer of ships would contribute in large measure to a better knowledge of skin friction. Although such work was very difficult to do on full-scale trials, it should be done whenever possible. A Pitot log with a sufficient extension would be a help, and, if another Pitot log was available, and both logs were arranged at a distance large enough to give an appreciable difference in boundary-layer thickness, it should be possible to measure local frictional resistance. The second step was then the correlation with the surface roughness, and he was much indebted to Dr. Todd for having published so many results of his work on surface roughness measurement in that paper and in a previous one.

Dr. R. W. L. Gawn, O.B.E., said that the paper dealt very comprehensively with steps that were being taken to improve ships. The plans had been thoroughly developed, but he hoped that the author would not forget the people on the job, who had to carry out the various researches. Some of the work was of a very long-term character, and, if the best results were to be obtained, the research workers must be animated by a real passion for their subjects; to keep them up to the mark, the objective should be kept well before them, and he suggested that it was not hydrodynamics *per se*, but the ship. He wished to mention one point in connection with roughness of hull, concerning which diagrams had been shown on the screen. In the Lucy Ashton paper presented at the Spring Meeting of the Institution of Naval Architects, some useful results were given of the measurement of the degree of roughness of the hull surface, and they were allied with actual resistance measurements of the ship. He hoped to give with his remarks in the discussion a diagram showing those measurements, together with the measurements of the surface of a propeller. That surface was smooth to the touch, but it was not smooth to the instrument. The particular propeller was one representative of the 20-in. series. It had been shown by deduction from the thrust and torque measurements that the

resistance of that surface fell on the turbulent skin-friction line; from which it might be deduced, therefore, that if a ship's surface could be made as smooth as that, the resistance of a short ship would be reduced by 12 per cent., and of a longer ship by greater amounts, up to 20 per cent. That provided some sort of goal.

He noticed that the resistance of a zinc-chromate surface was very near the turbulence line, and he would like to suggest that the author should include the results for the zinc-chromate surface on his diagram so that it might be compared with the propeller. Also, if that could be established as a sort of ideal surface for turbulent flow, the question of roughness would leave the realm of the hydrodynamicist and pass into that of the practitioner or the shipbuilder. He would be glad if Dr. Todd would elaborate on the pneumatic wave make-up. It was clear that, on a small installation, the waves were beautifully regular. Could they have an assurance that, on a large equipment, where there were massive working parts—blowers, valves, etc.—he would succeed in reducing the mechanical inertia to such an extent that the waves created would not suffer from lack of uniformity?

Professor A. F. Lindblad, Sc.D., thought that the paper compared very favourably with many papers of the kind, dealing with organisation, in that it showed that some work had been done in the matter of detecting the difference between turbulent flow and other types of flow, and in the research which was published on the friction of ships and models. He would not dare to say which of the friction curves he liked most, but it had been shown rather clearly that the Schoenherr line, after proper allowances, would give a good mean which the practitioner could use. When, however, he saw so many references to "boards," "panels," etc., he wondered how those who had to attend all those board and panel meetings ever found time to do a little thinking, bearing in mind that work could be delegated to other people, but the thinking could not be delegated. In the sub-section of the paper headed "Methodical Research into Hull Form" it was stated that "although the parent lines were selected from a number of models having acceptable resistance characteristics, it was found that in fairing the cross curves and contours some of this good performance had been lost." It was not possible to get one group of a few single models which would suit all the different block coefficients and to get good overall research. They must be put into smaller groups and the work done from those groups instead. It was mentioned in the same section of the paper that the Bureau of Ships, together with the Society of Naval Architects and Marine Engineers, had sponsored a programme for the computation, correlation and analysis of existing data on the resistance and self-propulsion characteristics of ship models. It is stated that "the geometry and resistance test results for some 150 different models have been compiled in a standard form suitable for analysis." Some were very good models, some were rather poor, but from them it was possible to select, and to determine which were the best features. Some years earlier, they had heard about a text-book which was to be published in co-operation with the Society of Naval Architects and Marine Engineers. What had become of that? Much had been said nowadays about bulb forms, and he would like to ask why the series 57 had been selected. Was there some kind of military advantage in fitting such bulbs to ships? He had done some research on those lines and had compared the bulb forms with other lines. There were many cases in which advantage was to be gained from small bulbs, and with large bulbs good results could be obtained, but in his opinion it was not good to have just a full form.

Dr. G. Hughes observed that it was stated in the paper that the stud method of stimulating turbulence was developed by the Ship Division of the National Physical Laboratory, and asked whether it was to be inferred from Dr. Todd's remarks that the Taylor Model Basin was using studs as the standard method of stimulation on model hulls. Although at Teddington the studs were used extensively, they were still using the trip wire as the standard method of stimulation in all commercial work; not because they thought it better than the studs, but because the work in the model range with which they were dealing showed that there was little difference. The studs were definitely superior to the trip wire at the lower speeds. They were engaged in a lot of work at those lower speeds, and for that work they were using studs. Dr. Todd referred to work in progress at the Taylor Model Basin, using studs at different distances from the forward edge of a flat plate in order to study the mechanics of turbulence stimulation. The transition zones were made visible by spraying the plate with a chemical indicator. That led him to ask how effective were those indicators and the hot-wire anemometer in showing the degree of resistance on the forms? Earlier, Dr. Todd stated that the experimenters were satisfied that the methods they used for the flow indications were satisfactory qualitatively, but not quantitatively; it seemed that, while they give a general indication of the type of flow, if they were to be used to decide what was the real degree of turbulence obtained, those flow observations must be linked directly with the corresponding resistance observations in the same tests. If that was not done, it was still not clear what the flow observations were telling them. Dr. Todd spoke of "mapping out the areas on a ship model or plank over which the flow is laminar, transitional or turbulent." Dr. Hughes did not think he meant that the flow could be transitional; as he understood it, the flow was either laminar or turbulent. Did he mean that, in the areas in which he described the flow as transitional, it was not laminar or turbulent, but something in between, the flow being at one instant laminar and at another turbulent? If that was the case, there were extensive areas of that so-called transitional flow. A good deal of work had been done recently on turbulence stimulation and resistance measurements, and he had been agreeably surprised by the remarkable stability of any one result, whether there was any laminar flow in the actual case or whether it was all turbulent.

While the investigations described in the paper were undoubtedly well worth while and would lead eventually to much greater knowledge concerning flow on ships' hulls, at Teddington they were not, at the moment, pursuing that particular approach; they intended instead to concentrate on the overall picture as given by the resistance results, basing their conclusions on the consistency or otherwise of those results. He commended that particular method to Dr. Todd, because he thought it would give the more immediate answer to the problems.

Mr. T. W. Bunyan, B.Sc., was sure that the engineers present would have listened joyfully to Dr. Todd's exposition, particularly in connection with the systematic explosion of the mystery which, for many years, had surrounded the aperture of a single-screw vessel. To engineers that was particularly important, because it was known that a tight aperture clearance behind the propeller could have most serious consequences. In tanker geared-turbine machinery, there might be one-, two- or three-noded induced torsional vibrations, distributed throughout the running speed. At Lloyd's Register of Shipping, in conjunction with the tank at Teddington, they had undertaken to try to sort out some of those propeller-excited shafting vibrations, and he hoped that Dr. Todd would include that problem also in his programme.

Professor K. S. M. Davidson said that he could not disagree more completely with Professor Telfer's remarks concerning skin friction; the formulation of skin friction that they did agree on was based on the Schoenherr line, and not Davidson. He had had a little to do with the Research and Development Board's functions, and agreed that the figure of 1,500 million dollars a year, as the expenditure on research and development by the Department of Defence, was a rather staggering figure. But one or two things must be kept in mind in regard to it. It included development as well as research, and that made an extremely uncomfortable complex with which to deal. For several years he had attempted to get some reasonably clear picture of the relationship between hydrodynamics and aerodynamic research in the United States; he had never attempted to assess completely what the relationship ought to be. He was convinced, however, that, at any rate until quite recently, the relationship was woefully inadequate so far as hydrodynamics were concerned. The Bureau of Ships' programme, which began to function only in the last year or two, was a step towards remedying the balance, at least to a point where they did not need to be ashamed of the lack of emphasis on hydrodynamics. They were still philandering to some extent in the United States in regard to the organisation of effort, particularly in a field such as that of hydrodynamics, which had no long history of considerable support behind it. In the aeronautical field, there was a long tradition; they had been trying to get hydrodynamics to a point where it was reasonably well recognised, and the change of administration mentioned in the paper was only one aspect. Since the war, there had been a good deal of manœuvring to find the right solution; so that, if the organisation charts, etc., which Dr. Todd had given appeared to be rather elaborate, probably that was part of their growing pains. They had an ambitious programme and the problem was to settle it down to a point where those who could contribute most could really do so.

Dr. Todd indicated that he would reply in writing.

(To be continued.)

LIGHTWEIGHT EJECTOR SEAT FOR AIRCRAFT.

For enabling aircrews to escape safely from high-speed aircraft, the Martin Baker Aircraft Company, Limited, Higher Denham, Uxbridge, Middlesex, have developed a lightweight automatic ejector seat weighing about 50 lb., considerably less than half the weight of their earlier Mark 1 (non-automatic) and Mark 2 (automatic) seats. Much of the weight saving has resulted from using a combined ejection gun and seat guide rail. The overall height of the new seat has been reduced to 40 in., enabling the pilot to see behind him over the top of the seat. The parachute pack, which is on the front of the drogue container (the drogue being used to stabilise and retard the seat after ejection) serves as a head-rest. To protect the pilot's legs from being blown apart by the airstream, snubbing units hold the legs tightly against the front of the seat pan during ejection. The pilot wears a webbing garter on each leg just below the knee; a nylon line, passing through a buckle on the garter, and through a snubbing box attached to the seat pan, is attached to a break-away point on the cockpit floor. On ejection, the snubbing boxes hold the lines tight after break-away. The other ends are released when the seat harness is released after ejection.

The method of ejection is similar to that used in the Mark 2 ejector seat, the principle of which was described on page 368 of our 171st volume (1951). It may be recalled briefly that the multiple-shot ejection gun is fired by the pilot pulling down a face screen, which serves to protect the pilot's head from forward and sideways movement, and also from the air blast. One second after ejection, a drogue gun is fired, withdrawing the drogue from its container. Provided that the seat is below 10,000 ft., the timing mechanism frees the drogue from the shackle at the top of the seat and also releases the pilot's harness from the seat. As the drogue is released from the seat, a line from it extracts the pilot's parachute from the pack, lifting him out of his seat. Above heights of 10,000 ft., a barometric control prevents the timing mechanism from releasing the drogue, thus enabling the pilot to be brought down quickly from high altitude and reducing the effects of exposure. A manual release for the harness is also provided.

50th Anniversary of Powered Flight.—To commemorate the first controlled powered flight by Wilbur and Orville Wright, which took place at Kitty Hawk on December 17, 1903, the Royal Aeronautical Society, in conjunction with the Royal Aero Club, will hold a dinner on Thursday, December 17, at the Dorchester Hotel, London. The dinner will be followed by a film, "The Story of the Century," produced by the Shell Film Unit in collaboration with the Royal Aeronautical Society. The film depicts the growth of flying and its impact on civilisation.

THE AMERICAN WELDING SOCIETY.

THE 34th annual meeting of the American Welding Society was held in Cleveland, Ohio, from October 19 to 23, under the presidency of Mr. Fred L. Plummer, M.Sc., who is the Director of Engineering at the Hammond Iron Works, Warren, Pennsylvania. In his presidential address, delivered at the opening session on October 19, Mr. Plummer —who, it was announced, had accepted office as President for a second year—reviewed the work of the Society during the previous twelve months and referred particularly to the rapid growth of its membership—now 9,349, representing an increase of 17·8 per cent. over the previous year. Among the awards conferred on the conclusion of the address was that of the 1953 Lincoln Gold Medal to Mr. Walter H. Wooding, superintendent of the Metals Section in the Industrial Test Laboratory at the Philadelphia naval shipyard, for his paper on "The Inert-Gas Shielded Metal Arc Welding Process." Thirteen cash prizes, ranging from 750 dols. to 250 dols., given by the Resistance Welder Manufacturers' Association, were also awarded. Of these, the first prize of 750 dols., was won by Mr. Chester A. Czohara, a welding research engineer with the International Harvester Corporation, for his paper on "The Design and Application of Edge Ring Welding." At the same session, Mr. R. B. Shepheard, C.B.E., B.Sc., Director of the Shipbuilding Conference, London, delivered the 1953 Adams Lecture on "Aspects of Welding Research in British Merchant Shipbuilding," an abridgment of which will be published in an early issue. The annual dinner of the Society was held in the Hotel Cleveland on Thursday evening, October 22, the chair being taken by the President, who, in the course of the evening, presented the Adams Lecture Award to Mr. Shepheard. The conference of the Society was held at Cleveland to coincide with the 35th annual National Metals Exposition in the city's Public Auditorium and formed part of the National Metals Congress in which the American Society of Metals, the Society for Non-Destructive Testing, the American Institute of Mining and Metallurgical Engineers, and the Special Libraries Association also took part. The Public Auditorium is a building of exceptional size, containing several large halls, but it was filled to capacity, there being some 500 stands. The spring technical meeting for 1954 of the American Welding Society will be held in Buffalo, N.Y., from May 4 to 8, inclusive, in conjunction with the Welding and Allied Industry Exposition. Particulars may be obtained from the national secretary of the Society, Mr. J. G. Magrath, 33, West 39th-street, New York 18, N.Y., U.S.A.

HISTORIC WORKS GATEWAY.—Peter Stubs Limited, Warrington, steel, file and wire makers, have received notification from the Ministry of Town and Country Planning that the entrance gate to their Rotherham Works has been scheduled as a building of special architectural historic interest. The gateway stands on a site which at one time was part of the office and stables of the house of Lord Howard, the first Earl of Effingham, Commander-in-Chief of Her Majesty's Fleet during the reign of Queen Elizabeth the First. The original date of the gateway is not known but in general design and construction it is typical of many buildings that were erected during the reign of William and Mary.

BUILDING RESEARCH IN INDIA.—The Council of Scientific and Industrial Research in India set up, in 1943, a Building Research Committee whose deliberations resulted in the staffing, in 1947, of a building research unit at the Thomason College of Engineering, now the Technical University, of Roorku, United Provinces, India. Part of the duties of this research unit was to design suitably equipped accommodation, and the foundation stone of the new Central Building Research Institute, Roorku, was accordingly laid in 1951. The Institute was formally opened in April last. The Director of the Institute, Dr. Billig, said in his address that immediate investigation into the techniques of prestressed concrete and the construction of corrugated shell-type structures would be carried out. The first Bulletin of the Institute has since been published and is available from the Council of Scientific and Industrial Research, New Delhi, India, price 1 rupee.

THE WORK OF THE GAS COUNCIL.

THE fourth annual report of the Gas Council for the year ended March 31, 1953, which was published by H.M. Stationery Office on Tuesday, October 27, at the price of 6*s*., shows that another nationalised industry has achieved a financial surplus on the year's working. This amounted to the net figure of nearly 2·272*l*. million on a gross revenue of 281*l*. million, 164*l*. million of which came from the sale of gas and nearly 80*l*. from the disposal of by-products. This result has not been obtained without difficulty, since shortages of coal, steel and cast iron, and the increasing cost of the first, still presented major problems. In fact, the increase in the pithead prices of coal which have amounted to about 17*s*. 9*d*. per ton since vesting date, are costing the industry an extra 25*l*. million a year, while the availability of good gas-making fuel is decreasing. Methods of increasing efficiency by the use of new processes and new sources are therefore wisely being sought. Already the replacement of obsolete plant and the concentration of production in larger units has enabled the gas output per ton of coal carbonised to be increased to 73·65 therms during the year under review, compared with 72·77 therms in 1951-52, an improvement which it may be pointed out is not due to better quality coal. As regards new processes, an extensive search is being made to discover whether supplies of natural gas are available in Great Britain in sufficient quantities to be of commercial value. Information is also being obtained on the long distance transmission of gas at high pressures, a matter which is, of course, important in connection with the utilisation of natural gas. Research is proceeding into processes for the complete gasification of coal and into new sources of supply, such as liquefied petroleum gas, methane and oil. The sales of gas during the year amounted to 2,523·7 million therms, compared with 2,513·3 million therms in 1951-52, although there was a falling off of 1·2 per cent. in domestic sales, the latter being partly ascribable to restrictions on the hire purchase of certain appliances. The number of consumers, however, increased from 12,120,847 to 12,273,273, 11,517,159 of whom were domestic.

PERSONAL CONTACT IN OVERSEAS TRADE.—Mr. G. M. Flather, President of the Sheffield Chamber of Commerce, in addressing the autumn general meeting of the Junior Chamber, said that personal contact in developing overseas trade was essential. He had visited 17 different countries for trade purposes since the war, and was convinced that some form of representation was vital for firms wishing to compete in overseas markets.

THE LATE MR. F. W. BOND.—We note with regret the death of Mr. Francis Willoughby Bond, B.A., B.A.I., which occurred on Friday, October 9. Mr. Bond had been connected with the Engineer's Department, Dublin Port and Docks Board, East Wall, Dublin, for 30 years, and for the past 10 years had served as engineer-in-chief. He was elected an associate member of the Institution of Civil Engineers of Ireland in 1931 and was transferred to the class of member in 1936. He had served on the Council.

AIR-CONDITIONING OF OFFICE BUILDING IN TORONTO. —The Manufacturers Life Insurance Company of Toronto, Canada, has recently brought into use a twelve-storey addition to their existing head office building, thereby increasing the floor space to 228,000 sq. ft. A feature of the new combined building is the air-conditioning, heating and cooling system installation which is stated to be the first of its kind in Canada. In this system heating and cooling is by means of aluminium panels behind which hot or cold water is circulated, cold water also being circulated behind the lighting panels in the ceilings so as to remove the heat generated. Cooling of the cold circulating water is effected by a 750-h.p. refrigerating unit rated at 800 tons a day, while heat is provided by two oil-fired water-tube boilers delivering low-pressure steam at 42 lb. per square inch to heat exchangers located in the old and new portions of the combined building. Since heating and cooling is mostly by radiation, the supply of conditioned air is about half that which would normally be required, while that supplied is for controlling humidity and providing a sufficient quantity of fresh air. The system is stated to maintain a room-temperature of 70 to 75 deg. F. with a relative humidity of 50 per cent. in summer and 30 per cent. in winter.

RESEARCH ON CAST IRON.

WORK carried out during the past few months on the control of respirable dust from pedestal or stand grinding wheels, commonly used in foundries for cleaning castings, has been attended with striking results. It has been shown that, by means of an external extractor unit situated near the point of origin of the dust, the amount of dust in the operator's breathing zone is about the same, whether the wheel is in operation or not. It has been demonstrated, moreover, that the dust in the breathing zone is little different from that of the outside atmosphere. It is stated in the recently-published 32nd annual report of the British Cast Iron Research Association, Alvechurch Birmingham, for the year ending June 30, 1953, that arrangements are now in progress for the commercial manufacture of this extractor unit. It is of interest also that an active programme of work on air flow in the neighbourhood of foundry knock-out points, where considerable dust and steam are normally generated, has been begun.

Following the development of satisfactory vacuum-fusion apparatus and molten-metal sampling technique, work on the influence of gaseous elements in cast iron has made considerable progress. Significant differences in oxygen and in nitrogen contents have been detected and research has shown that the well-recognised graphitising influence of small additions of aluminium, in the past attributed to a deoxidising effect, can be almost entirely related to a combination with nitrogen. In the sphere of shell moulding, the report states that the industry is showing considerable interest in this relatively new process, and the Association has constructed suitable apparatus for making shell moulds where special reasons exist for the production of test castings by this method. Also of interest to founders are the short educational courses on sand testing and control for representatives nominated by member firms. These courses have been continued as for some years and five have been held during the twelve months covered by the report. Each course was attended by some twelve representatives and lasted for nearly one working week. About 200 representatives of member firms have now attended these courses.

Work has been carried out on the impact properties of nodular iron with varying silicon and phosphorus contents, and the embrittling influence of these elements demonstrated. It has been shown that the results obtained can be interpreted in terms of two transition temperatures, one related to the energy required to propagate a crack and the other to the energy required to initiate a crack. It has been found that the unnotched impact test can be used to indicate the energy required to form a crack, and the notched impact test to indicate the energy required to propagate a crack.

Research work carried out during the year on the soundness of iron castings has been mainly concerned with changes in mould dimensions when molten iron is poured into a mould. The investigation has shown that green-sand moulds dilate and that the casting follows this dilation. The dilation of the mould cavity increases with the moisture content of the mould and is related to the migration of moisture from the mould at the mould-metal interface. Experiments to inhibit this mould dilation are continuing. During the year the number of inquiries from the industry dealt with by the Association's development department has been well maintained. It is sometimes difficult for a firm designing a new part to obtain a prototype casting in a trial material sufficiently quickly to enable tests to be made in advance of large-scale production. Several such castings have been made at Alvechurch during the past twelve months; they have included television-screen moulds weighing 70 to 80 lb., a magnetic casting in annealed nodular iron weighing 150 lb., a 30 per cent. chromium extrusion die weighing 100 lb., and some motor-car cam pallets weighing half an ounce. Larger and more complex prototypes are dealt with by the staff of the development department in conjunction with the foundries of member firms, particularly when special materials are involved.

INTERNATIONAL MOTOR SHOW, EARL'S COURT.

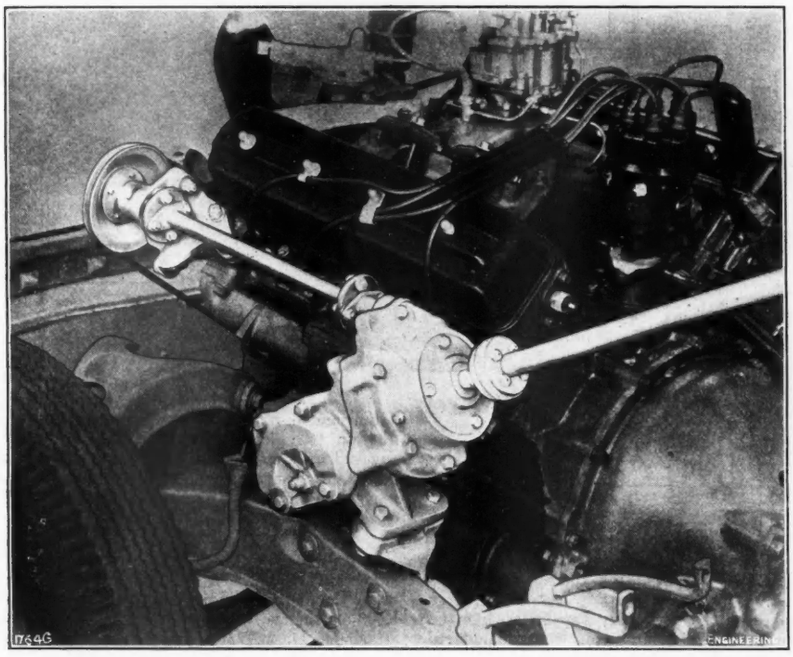


FIG. 23. STUDEBAKER MECHANICAL POWER STEERING UNIT.

ENGINEERING DEVELOPMENTS AT THE MOTOR SHOW.

(*Concluded from page* 567.)

III.—MEDIUM AND LARGE CARS.

As American manufacturers customarily present their new models about the turn of the year, the cars seen at the London Show are usually those which have been current since the previous January, but this year the Chrysler group and Hudson both showed their 1954 lines at Earl's Court.

The Studebaker is the only American car which appears to have been influenced by European ideas. It has a distinctly Continental air in its low build, deep propeller-shaft tunnel and separate rear seats. Its low sloping bonnet also provides especially good driving vision. With this exception, the current American formula seems to treat the car as far as possible as a sitting room on wheels, with seats closely modelled on the domestic settee. One wonders if the great size of the interior, the far-away windscreen and the long, high bonnet may not conspire with the radio and heater, the power steering and automatic transmission, to create a dangerous sense of isolation in the occupants. The driver of the smaller and more nimble European car may be more vulnerable in the event of an accident, but his closer contact with his surroundings may well assist him in keeping out of trouble. The American settee-type seats do not seem to be designed to support the occupants in any sudden changes of direction, even if the steering gear permitted such changes, which is rarely the case.

POWER-ASSISTED STEERING.

Power-assisted steering is now offered as an optional extra on a high proportion of American cars. Most of the systems are hydraulically operated, but Studebaker use a mechanical servo. Chrysler were first in the field in 1951 with power steering, which is now available on all the group's cars. Movement of the steering arm is assisted by pistons under hydraulic pressure generated by an engine-driven pump, and the effort required from the driver is maintained at a practically constant low level irrespective of the resistance encountered at the road wheels. This is criticised by some drivers as giving no "feel" of what is happening at the road wheels while driving. The General Motors system, which is also hydraulic, makes the driving effort proportional to the total resistance and therefore maintains more of the feel of a conventional steering gear.

The Studebaker system (Fig. 23) is much simpler, employing two contra-rotating multi-plate clutches driven by a belt from the engine. As the steering column is turned, a simple linkage brings in one of the two clutches, supplying power to supplement the driver's effort in the appropriate direction. It was at first thought that the use of power steering would eliminate the excessively low steering-gear ratios used on American cars, but it was found that drivers were so accustomed to making many turns of the wheel that high gearing could not safely be used, and in some cases the ratios have had to be lowered again to something nearer the ratios used with manual unassisted steering.

TRANSMISSIONS AND GEARBOXES.

The history of the hydro-kinetic torque converter in its automobile applications recalls that of the gas turbine as applied to aircraft propulsion. Both are devices of much publicised simplicity which in their practical application have had to be elaborated into mechanisms of considerable complexity. The most popular arrangement for American transmissions is a single-stage converter in conjunction with a planetary gearbox giving two speeds and reverse, but in some cases three speeds are provided in the gearbox, with automatic changing between ratios. A few, like Packard, whose Ultramatic transmission was shown at Earl's Court in part section, provide a plate clutch to lock the converter out of action and increase the efficiency of the transmission in top-gear operation.

Chrysler have now taken the wheel full circle by introducing a low-priced transmission for Dodge and Plymouth cars which consists of a single-stage converter *plus* a conventional clutch and manually-operated three-speed synchromesh gearbox. On these cars, the clutch pedal is therefore retained. The converter with two-speed planetary box is still supplied on the more expensive Chrysler and De Soto cars. Buick use a two-stage converter in conjunction with a planetary gearbox, and this transmission has been fitted to some Cadillacs as a temporary measure following the serious fire at the General Motors Hydramatic plant earlier this year. The Cadillacs at Earl's Court were, however, equipped with the Hydramatic transmission, consisting of a fluid coupling and four-speed epicyclic gearbox.

Rolls-Royce Limited have extensively modified the General Motors Hydramatic transmission for their own purposes and are now making it in England. It can be supplied at an extra cost of 70*l.*, plus purchase tax, on Rolls-Royce and Bentley cars and will, no doubt, be available for other applications. It will be recalled that this transmission was used on certain armoured cars during the last war. The control system has been modified to give three driving ranges. With the steering column lever at the position marked "4" on its quadrant, the gearbox changes automatically up and down through its four ratios, the timing of the changes being governed by the degree of throttle opening. At position "3," top gear is not engaged unless the car speed exceeds 65 m.p.h. This is useful in crowded traffic, or on mountain roads. Position "2" restricts the car to first and second gears and can be used to obtain engine braking on long descents. Changes from one range to another can be made at any time.

The Laycock de-Normanville over-drive, originally introduced on touring cars, is proving important as a means of providing a high maximum speed for moderately-powered sports models without the use of a very high axle ratio which would entail an unacceptable sacrifice of top-gear acceleration. The overdrive, shown in Fig. 24, on page 588, is a planetary unit which can be mounted at the rear of the gearbox, or, as in the case of the Jowett Jupiter, part way between the gearbox and rear axle. The over-drive is electrically controlled and can be operated by a simple switch on the instrument panel, as on the Austin-Healey, by a separate lever, as on the Jupiter, by a switch on the gear lever (Sunbeam Alpine), or by a side-ways movement of the main gear lever (Jensen and Standard Vanguard). It is entirely under the driver's control and changes can be made without the necessity for closing the throttle. In direct drive, power is transmitted from the input shaft through a uni-directional clutch employing rollers and inclined planes, to the planetary annulus which is connected to the output shaft. The planet carrier is connected to the input shaft. In addition, there is a spring-loaded cone clutch which locks the sun wheel to the annulus, thus maintaining engine braking on the over-run, when the roller clutch would be inoperative.

When the over-drive is selected, hydraulic pressure draws back the cone clutch against the action of the springs, so that its outer surfaces engage with the transmission casing, thus locking the sun wheel stationary. The planet carrier and planet wheels now cause the annulus to be overdriven at a higher speed. In over-drive the roller clutch acts as a free-wheel between the planet carrier and annulus but engine braking action is maintained on the over-run because the sun wheel is locked. Hydraulic pressure to engage over-drive is provided by a plunger-type pump driven by a cam on the input shaft. This supplies oil under pressure to a cylindrical accumulator chamber within the casing. Control can be effected by a direct mechanical linkage operating the hydraulic valve, by a switch operating a solenoid, or by an electrical centrifugal governor with a solenoid to give automatic engagement at pre-determined speeds, with provision for over-riding control by the driver.

CHASSIS AND SUSPENSION SYSTEMS.

Several unusual constructional features are found on the new Type-180 Mercedes Benz; in particular, there is a very bold use of rubber to insulate the body from road noise and vibration. The front suspension, steering and power unit are mounted together on a stirrup-shaped cradle formed of steel pressings, which is attached to the underside of the unit body-chassis structure by three mountings which contain large rubber cushions. The whole front-end mechanism is thus rapidly removable for repair. This arrangement is shown in Figs. 25 and 26, on page 589.

The car has the usual Mercedes swing-axle rear suspension, but longitudinal radius arms are added to connect the outer ends of the axles to the frame.

The final-drive casing is attached to the body structure by a single large rubber mounting, and the radius arms are also attached via large rubber cushions. Normally such a suspension layout would call for some torsional flexibility in the radius arms such as is provided by the steel blades used on the Volkswagen, but apparently the relative movements due to wheel deflection are accommodated on the Mercedes by distortion of the rubber cushions on the drive casing and radius arms.

An interesting feature of the Riley Pathfinder (shown in Fig. 27, page 592) is the way in which the chassis frame has been swept out to full width between the front and rear wheels to permit an unusually low seating position. Head room is adequate, although the overall height of the car is only 60 in. This car departs from previous Riley practice in having coil-spring rear suspension instead of half-elliptical springs. An open propeller shaft and rigid axle casing are used, thrust being applied by long radius arms pivoted near the centre of the chassis. Lateral location of the axle is by a Panhard rod. Although rack-and-pinion steering works admirably on small cars, it is difficult to avoid the transmission of road reaction to the steering wheel on larger cars, despite efforts which have been made with spring-loaded friction pads to damp the action of the rack, and on the Riley Pathfinder cam-type steering is used instead of the former rack and pinion.

Laminated torsion bars mounted longitudinally are used with a conventional wishbone suspension system on the front of the Lanchester Leda and Daimler Conquest. George Salter and Company, Limited, who make them, also exhibited an alternative arrangement, with a single bar carried in a chassis cross-tube, similar in principle to the twin-bar arrangement used on the Volkswagen. Laminated bars have some self-damping properties and are easily clamped at the ends, eliminating the expensive splines needed with round bars. William E. Cary, Limited, have taken a licence for variable-rate suspension under the French Grégoire patents. This can be applied as a principal suspension. One arrangement consists of a swinging arm working with a coil spring in tension, with pivot points so arranged that the spring rate rises with deflection, and a substantially constant spring frequency is maintained throughout the range of vehicle loading. The method can also be applied as an auxiliary to a conventional suspension system, as shown in Fig. 28, page 592, and a coil spring in tension was shown linked to the rear suspension of an Austin A40 car. Conversion kits are also under construction for the Austin A90 and the Mark VII Jaguar.

On some telescopic suspension dampers, efforts are being made to improve cooling by providing fins on the damper body, but it would appear that their efficiency must be quickly reduced when they become clogged with mud. The Standard Eight has its dampers, which are of the double parallel-piston type, mounted on the rear axle, with operating arms connected to anchorages on the body. This avoids the need for heavy damper mountings and local reinforcements on the sheet-steel body structure. It would appear to entail an increase in aeration of the fluid, but this is a subject which has been given intensive study by damper manufacturers and a similar arrangement has been used with apparent success for some time on the Australian Holden car.

Wheels and Accessories.

The trend towards road wheels of smaller diameter continues. Several recent models are equipped with 13-in. wheels. They are lighter and cheaper than larger wheels, they reduce unsprung weight, and by reducing the size of the wheel arches they make more space available in the body. They also lower the centre of gravity but they tend, of course, to fall further into pot-holes than large wheels. A higher rate of tread wear would be expected, because of the greater number of revolutions per mile, and at least one Continental constructor delayed adopting 13-in. wheels for a time because of inability to obtain tyres with the requisite extra tread thickness. Tyre manufacturers maintain that a thicker tread would be subject to distortion which would increase the rate of wear and defeat its object.

INTERNATIONAL MOTOR SHOW, EARL'S COURT.

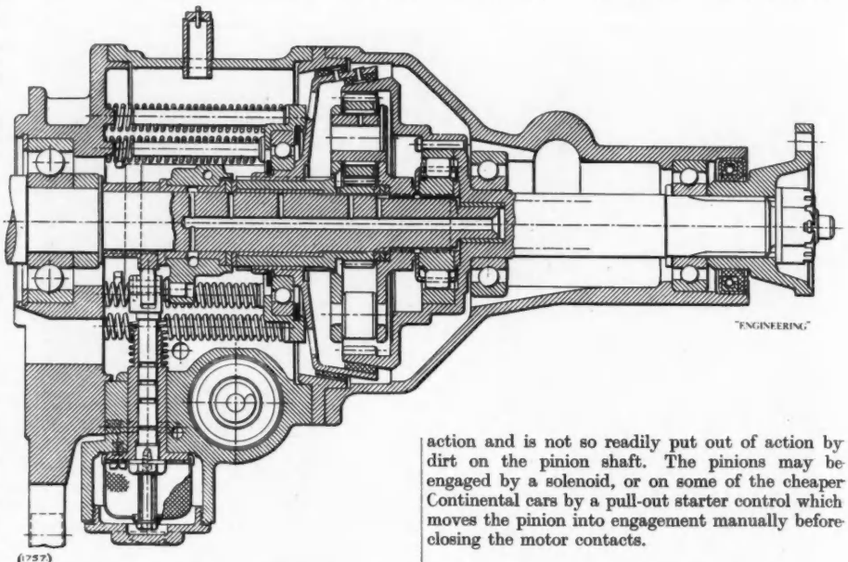


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Fig. 24. Laycock de-Normanville Over-drive Unit.

Brakes on the new Riley Pathfinder, like those on the Mark VII Jaguar, are of Girling manufacture with two trailing shoes at the front. As twin trailing-shoe brakes have no "self-wrapping" effect, they are claimed to be less subject to fade. The higher pedal effort required is supplied by the use of a vacuum servo connected to the engine induction manifold. Such servo installations are used on several American cars, the Mercury being one of the most recent applications, and where fluid transmissions are used a vacuum reservoir is usually employed to guard against the engine stalling on a long descent. These reservoirs have not so far been employed on British private-car installations. Another difficulty which has been experienced is the freezing of moisture which collects in the servo cylinder during cold weather. This has been cured on Jaguar cars by drawing air from a filtered intake inside the car.

Most cars in Britain have been fitted with semaphore direction indicators, which were practically the only type complying with the existing regulations, but cars for export are fitted with the flashing-light signals which are widely favoured in America and on the Continent. This system is shortly to be legalised in England, and Lucas have a flasher switch to operate blinking lights. The unit is operated by linear expansion of a wire which is heated by an electric current. The wire controls the movement of an over-centre spring blade carrying a contact. When the indicator switch is turned, the current flows through the wire, which expands until the spring blade snaps over, closing the contacts to illuminate the lamps and cutting off the supply to the hot wire. Current to the lamps flows through a small solenoid unit which actuates a plunger switch operating the instrument-panel warning lamp. When the hot wire cools down, the spring blade is again deflected, opening the lamp contacts, restoring current to the wire, and restarting the cycle. The unit gives about thirty flashes per minute. Bosch also showed a flasher unit in which the lamp contacts are carried on bi-metallic spring blades. The blades are surrounded by small heater coils of about 2-watt consumption, which cause them to bend and close the contacts to the lamps, simultaneously cutting off the heater current. This system also operates at about 30 flashes a minute.

Britain now seems to be the only country depending entirely on starter motors with inertia pinion engagement of the Bendix or modified Bendix type. Continental and United States manufacturers make wide use of the positively-engaged pinion, which appears to be quieter in action and is not so readily put out of action by dirt on the pinion shaft. The pinions may be engaged by a solenoid, or on some of the cheaper Continental cars by a pull-out starter control which moves the pinion into engagement manually before closing the motor contacts.

Petrol and Diesel Engines.

The M.G. Magnette is the first car to be equipped with the British Motor Corporation's B-series 1,500-c.c. engine, which, with different carburation arrangements, will also power future Morris and Austin models. It will be followed by two larger engines, designated the C and D, to re-equip the group's larger models. The bore and stroke of the B engine are 73·025 mm. and 89 mm., respectively, so there is no whole-hearted acceptance of current arguments in favour of square or over-square engines. The first engine of the series is the A-type 800-c.c. four-cylinder unit used on the Austin A30 and Morris Minor. It has a rather shallow crankcase casting and the connecting rods are offset on the crankpins—an unexpected feature on a new engine designed apparently without restrictions imposed by prior tooling commitments. After all, every production engine is destined to be developed for higher duties as its career proceeds, and this little Austin engine, originally designed before the Austin-Nuffield merger for installation in a saloon car weighing 1,344 lb., is already installed in a Morris Minor station wagon weighing some 500 lb. more.

Power outputs have been raised on several British engines, by raising compression ratios, and sometimes by fitting larger valves or extra carburettors. The Lagonda has been given an engine of 3-litres swept volume in place of the former 2·6-litre unit. Rover have evolved their "90" engine of 2,638 c.c. as an alternative to the "75" unit of 2,103 c.c. while retaining the same basic components. The stroke is unchanged at 105 mm. but the bore is increased from 65·2 mm. to 73·025 mm. and this has been achieved by re-spacing the bores, without cutting down the cylinder-wall thickness or unduly restricting the water passages. Instead of offsetting the connecting rods on the crankpins, the bearing lengths have been reduced, and, to compensate for the higher duty, copper-lead bearings are used in place of the steel-backed white-metal shells on the "75." En 110 steel is used for the crankshaft instead of En 100 on the smaller engine, and the crankpins are hardened.

The growing popularity of Diesel engines on European cars was exemplified by the Mercedes-Benz 170 SD, the Fiat 1400 (which is illustrated in Fig. 29, page 592) and the Borgward Hansa, all shown with four-cylinder Diesel engines of less than two litres capacity. All these engines use a pre-cell type of combustion chamber with heater plugs to ensure easy starting, and they employ a fair proportion of components common to the petrol units with which they are interchangeable. In some countries where Diesel oil carries a much lower tax than petrol, such cars can be operated for approximately the same fuel costs as those of a small motor-cycle, but even in England, where Diesel

INTERNATIONAL MOTOR SHOW, EARL'S COURT.

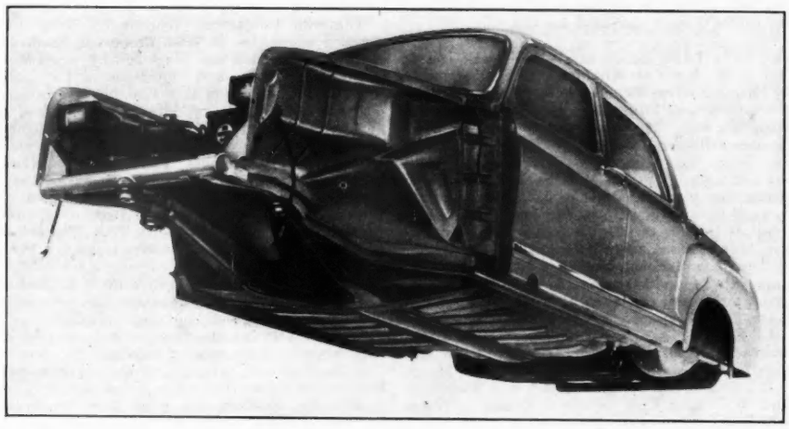

FIG. 25. MERCEDES-BENZ CHASSIS-BODY UNIT, SHOWING THREE RUBBER MOUNTING POINTS.

FIG. 26. MERCEDES-BENZ FRONT AND REAR UNITS, SHOWING FRONT SUPPORT BRIDGE.

oil is heavily taxed, the superior economy and durability of the Diesel engine are inducing many operators to accept the noise and rougher running of the Diesel unit. The Turner range of two-stroke engines for vehicle applications has already been described in ENGINEERING (pages 385 and 419, September 25 and October 2, 1953). The Perkins P4 is operated successfully in London taxi-cabs, and Perkins engines are also being sold as conversions for larger cars like the Humber Super Snipe, but Standard are the first to manufacture a Diesel car in England for private use. It was announced during the Show that the Vanguard estate wagon will be available with a Diesel engine, presumably based on the unit used in the Ferguson tractor.

Two engines on the Coventry Climax stand in the motor-boat section attracted special attention. They are of lightweight construction, and although at present adapted as power units for portable fire pumps, they would be suitable for use in racing cars. The larger unit, shown in Fig. 30, page 592, is a V-8 of 2,477·5 c.c., which conforms with the requirements of the International Grand Prix formula which is to come into force next year. In industrial form it should give an output of about 190 h.p.; but as a racing engine with a compression ratio of 11 to 1 its output should be approximately 250 brake horse-power, delivered at 8,500 to 9,000 r.p.m.; an epicyclic reduction gear is provided to bring the drive-shaft speed down to a range acceptable for current clutches and gearboxes. The crankcase and cylinder blocks are formed as a single casting in RR50 aluminium alloy with inserted wet cylinder liners. The cylinder heads are in the same alloy and have hemispherical combustion chambers, with inclined valves which close under the action of double-hairpin valve springs and are opened by thimbles over the valve stems operated directly from the camshafts. The four camshafts are gear-driven and in the centre of the V is a magneto, supplying one plug per cylinder, which is driven through a torsionally-flexible hollow shaft from the timing gear.

Similar methods of construction are used on a small four-cylinder engine of 1,000 c.c., driving a portable fire-pump unit and weighing only 180 lb. This pump set can be carried by two men and gives twice the output of similar pumps of the last war. It has at present a single overhead camshaft but may later be adapted as a racing-car power unit with twin camshafts and the swept volume increased to 1,100 c.c.

AMERICAN DEVELOPMENTS.

The Ford X100 experimental car is a typical example of the research projects on which the American industry is now spending great sums of money. These cars afford a valuable means of giving practical tests to new ideas. They also allow manufacturers to gauge public reaction to new features in style and equipment before investing in the very expensive tooling required for mass production. To this extent they are an insurance policy against wrong guesses like the Chrysler "Airflow" and the "pregnant" Buick cars—unsuccessful models which have become legendary in American automobile engineering.

Some features of the Ford, although new to the British public, are already widely used in the United States. One is the radio telephone by which the driver can make or receive calls on the national telephone network. These are widely used by contractors' representatives on construction sites and by others whose work takes them away from established telephone lines. Incoming calls on the Ford are signalled by a bell, but they can be arranged to sound the horn when a car is parked. If the driver does not pick up the receiver in fifteen seconds the ringing ceases but a light on the facia warns him that he has been called.

Another feature also in common use in the United States is the "homing" radio, which tunes itself automatically to the local station and then retunes to the next station as the car proceeds on a long journey. The transparent sliding front portion of the roof is closed automatically if it starts to rain while the car is parked. This is effected by a rain-sensitive spot similar to that used to raise the folding head of the General Motors car Le Sabre. In principle this consists of a strip of salt-impregnated webbing which contains a grid of electrically-charged wires. A drop of water creates a brine solution which bridges the gap between two of the wires, allowing current to flow and operating a relay which sets an electric motor in motion. The sliding roof, the four-wheel jacking system, the seat sliding and lifting mechanism, and the raising of the bonnet and luggage-boot lid are all performed by screw jacks driven by electric motors and not by hydraulic pistons commonly used for such purposes in current American production. Besides the usual heating and ventilation system there is provision for heating the seats electrically.

The V-8 engine is based on the current Lincoln unit; with a compression ratio of 8·5 to 1 it develops 300 brake horse-power, sufficient to propel this 5,900-lb. vehicle at over 100 m.p.h. Five carburettors are used. In the centre of the group is a standard unit which supplies the engine at speeds up to 60 m.p.h.; the others are brought in progressively by the throttle linkage until at full bore the mixture is being supplied through twelve venturis. The transmission, developed from Lincoln equipment, has a torque converter and three-speed epicyclic gearbox with automatic change.

Front suspension is similar to the Lincoln, the design of which is unusual for American practice, having a yoke piece pivoting in ball joints on the ends of the wish-bones in the manner used on Jaguar cars, among others in Europe. This eliminates the need for a separate king-pin. Steering is power assisted. The front-wheel brakes are cooled by thermostatically-controlled blowers which cut in when their temperature rises above 150 deg. F. The electrical equipment is said to contain eight miles of wire and weighs 665 lb. The rear axle is a De Dion layout of an old kind not seen recently, except on an American light delivery vehicle. The brakes and final drive casing are mounted on the chassis.

FILM ON ROAD-MAKING MACHINES.—A film shown recently by Road Machines (Drayton), Ltd., West Drayton, Middlesex, deals with the advantages of their mono-rail transporter, dump truck and weighbatching plant. The mono-rail transporter is in the form of a simple truck that can be tipped sideways for unloading. It is driven by a small single-cylinder petrol engine, and runs on a steel track of deep section to give the necessary stability. The track can be quickly laid over most surfaces.

NOTES FOR SPEAKERS ON FUEL.—Some useful "Notes for Speakers," intended to assist those in the electricity supply industry and elsewhere to produce some telling arguments on the fuel position, are contained in a pamphlet, copies of which can be obtained from the British Electrical Development Association, 2, Savoy-hill, London, W.C.2. Due to the pressing need to economise coal resources, there has been much inquiry since the war into the causes of waste and into possible courses of action which might help to reduce it. To a large extent this inquiry has centred on the comparative merits and overall efficiencies of electricity, gas, coal and coke. This booklet is an attempt to answer some of the allegations which have been made by critics of electricity.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

PROPOSED EXTENSION AT GLASGOW UNIVERSITY.—In a letter to graduates outlining various aspects of developments at Glasgow University, Sir Hector Hetherington, K.B.E., D.L., LL.D., D.Litt., the Principal, points out that "whenever 'Chemistry' can vacate the 'temporary' hutments which for more than 30 years have disfigured the south-east corner of the main front, these will come down to make room for the desperately needed extension of the Engineering Building." Sir Hector added that nearly 10 years had passed since plans had been drawn up and the engineering industry of the West of Scotland subscribed 230,000*l.* which would then have met almost the whole cost of the building. It would not do so now—not by half, but they had good hopes that as soon as the site were cleared, they would, at long last, begin.

ELECTRIC TRANSMISSION LINE OVER CUAN SOUND.—The North of Scotland Hydro-Electric Board have applied to the Minister of Transport for his consent to the erection of an overhead 11-kV transmission line which will cross Cuan Sound about 250 yards north-west of the ferry between the Island of Luing and Cuan on the Island of Seil. A new vehicular ferry service was inaugurated at Cuan a few weeks ago.

NEED FOR ROAD IMPROVEMENTS IN SCOTLAND.—The hope that the Government would soon be in a position to announce schemes for "substantial road improvements in Scotland" to meet the demands of trade, transport, and industry for such developments as the Clyde vehicular tunnel, the Forth road bridge, and the improvement of roads in the Highlands and Islands and between Glasgow and Stirling was expressed on October 24 by Mr. Henderson Stewart, Under-Secretary of State for Scotland. Mr. Stewart, who was proposing the principal toast at the annual dinner of the Road Haulage Association, Ltd. (Scottish Area), said that the Government were fully conscious of the urgent need for substantial improvements and regretted that so far it had been impossible to allocate funds for such schemes.

IMPROVEMENT OF PRE-FABRICATED HOUSES.—Mr. Neil Sutherland, burgh architect of Kilmarnock, by conceiving the idea of building a brick "skin" around pre-fabricated houses, leaving a cavity of two inches between it and the original wall, has perfected what is said to be a relatively cheap method of giving these houses the life span of ordinary council houses. Two years ago Dr. B. R. Nisbet, medical officer of health for Kilmarnock, complained that people in pre-fabricated houses had a higher incidence of illness than those in other houses.

BRIDGE OVER TWEED AT PEEBLES.—The Fotheringham Footbridge over the river Tweed at Peebles is of tubular steel and has a span of 106 ft. It was formally opened on October 24 by Provost P. Daniels. Mr. John Sibbald Fotheringham, a native of Peebles and a former mayor of Johannesburg, gave 5,000*l.* in 1948 for the construction of the bridge.

CLEVELAND AND THE NORTHERN COUNTIES.

PROJECTED TUNNEL UNDER TYNE.—The South Shields Chamber of Trade have asked the local authority to reopen the question of building a tunnel under the Tyne between South Shields and North Shields. This scheme was under constant discussion for some years before the war, but the Government eventually decided to build a tunnel four miles further up the Tyne between Jarrow and Howdon. The Tyne Improvement Commission are being urged by the local committee of the Confederation of Engineering and Shipbuilding Unions to abandon their decision to discontinue one of the two ferry services between North and South Shields which is being worked at a loss.

WORK OF NORTHERN GAS BOARD.—At a Press conference held at Newcastle-on-Tyne to discuss the annual report of the Northern Gas Board, Mr. E. Crowther, the chairman of the Board, stated that gas charges in the North-East, which were the lowest in the country, would remain unchanged for the time being, despite the recent 10 per cent. rise in coal prices. It was the Board's intention to avoid further increases in gas charges, but if there were further substantial rises in coal prices, the Board would be confronted with a difficult position. The average price of gas in the Northern Board's area was 11·43*d.* a therm compared with 15·6*d.* for the rest of the country. Mr. Crowther added that the Gas Board were investigating the possibility of storing gas in gas-tight underground cavities from which salt had been extracted for chemical works. In the United States, he stated, gas was pumped into old oil wells during the summer months and withdrawn in the winter to meet increased demand.

THE LATE LADY READHEAD.—The death has occurred at her home at Whalton, Northumberland, of Lady Mary Evelyn Readhead, a director of John Readhead and Sons, Ltd., the South Shields shipbuilding and repairing firm. She was 69 years old and the widow of Sir James Halder Readhead.

THE LATE MR. F. SWIFT, M.B.E.—Mr. Frank Swift, of Darlington, who retired about six months ago from the post of consultant with the Darlington Forge Ltd., has died at the age of 66. He joined the Darlington firm in 1901, became asistant foreman in the foundry in 1912 and head foreman in 1922. In 1926, Mr. Swift was appointed foundry manager. Owing to ill-health he gave up this post on March 31, 1952, but continued with the firm as consultant. Mr. Swift was awarded the M.B.E. in 1943. During his 50 years of service he was actively concerned with the structural steel castings for such ships as the Oceanic, Titanic, Mauretania I, Lusitania and the Queen Mary and Mauretania II, and H.M. ships King George V, Prince of Wales, Illustrious and Victorious.

THE LATE MR. T. H. DONKING.—The death of Mr. Thomas Huddart Donking has occurred at Middlesbrough at the age of 78. He had been connected with the shipping industry for more than 60 years and was one of Middlesbrough's first chartered shipbrokers. He was the founder of Constantine and Donking Steamship Co. Ltd., and later started T. H. Donking and Sons Ltd. At the time of his death, he was a member of the Tees Conservancy Commission and the Tees Pilotage Authority.

LANCASHIRE AND SOUTH YORKSHIRE.

ROLLING-MILL MODERNISATION.—An extensive modernisation scheme is being carried out at the works of the Tinsley Rolling Mills Co., Ltd., Sheffield. Already the sheet mills have been electrified and in the place of the steam plant a modern gas furnace will be installed. The latest type of ancillary plant will be provided.

UNPROFITABLE CANTEENS.—The industrial-canteens section of the Sheffield Chamber of Commerce have been considering the question of losses on the running of some works canteens. Employees have not been using them so regularly since it was necessary to raise some of the charges. The Chamber of Commerce secretary, Mr. A. E. Hahn, says that there is some uneasiness about the canteens. Statutory obligations on the part of firms to provide them are not now the same as during the war period, and he suggests that the best advice for workpeople having a good canteen is to use it. Canteens could then be run more economically even if they were not self-supporting. The view in industrial circles is that canteens should be self-supporting, excluding lighting and similar costs.

THE LATE MR. C. A. GARDNER.—Mr. Charles Albert Gardner, who has died at Sheffield, aged 82, was a director of the Sheffield Magnet Company, which he founded in 1914, and a director of the Gardshaw Foundry, Ltd., of Beighton. In 1897, he acquired the business of John Clark & Co., Ltd., Sheffield, manufacturing chemists, and supplied heavy chemicals and a wide range of oils and paints to Sheffield and district steelworks.

EMPLOYMENT OF ELDERLY.—Many elderly skilled men who had been retired because of advancing years have been seeking vainly employment which is not available in Sheffield because of conditions imposed by insurance companies, and a general disposition on the part of employers not to take the risk of taking elderly who might be prone to accidents. The Rotherham and District Employment Committee, however, have been making special efforts to place elderly men in work and have recently found employment for nine men over the age of 60. The oldest is a man of 71.

THE MIDLANDS.

ELECTRICITY LOAD SPREADING.—Unless exceptionally severe weather is experienced, there will be no compulsory electricity load spreading in the Midlands this winter. This is stated in a circular letter sent to 3,000 firms in the area by Major C. R. Dibben, chairman of the Midland Regional Board for Industry. Industrial consumers of electricity, however, are asked to do all they can to reduce the load in the peak hours during the period from mid-November to the end of January. A reduction of 10 per cent. in the peak load is desirable, and firms having private generating plant are urged to use it to the full at the times when the load on the public mains is heavy.

TRAINING COMMITTEE WOUND UP.—The foundry training committee at West Bromwich, Staffordshire, which was founded five years ago by representatives of local employers and employees in the industry, and the local education authority, has been wound up. The committee secretary, Mr. V. W. Williams, states that the decision to bring the work of the committee to an end was the result of lack of support from local industry. The National Foundry Craft Training Centre at West Bromwich is not affected by the committee's decision. It is run under the auspices of the West Midlands Ironfounders' Association, and is continuing its work of training boys from all parts of the country to become foundry craftsmen.

FACTORIES FOR LETTING.—Several local authorities in the Midlands have included, in their development plans, schemes for building factories which would be let to manufacturers, and, in one or two cases, buildings have actually been erected, and are in occupation. The idea has now extended to the northern part of the Black Country, where the Urban District Council of Aldridge, Staffordshire, have been recommended by their planning committee to erect factory units in two industrial estates in the area.

BIRMINGHAM METALLURGICAL SOCIETY'S JUBILEE.—The golden jubilee of the Birmingham Metallurgical Society was celebrated on October 19, by the holding of a meeting at which four papers were given by past presidents of the Society. A dinner followed the meeting. The Society was founded by a group of about 60 students and teachers at what was then the Birmingham Municipal Technical College, in 1903. The Society was incorporated in 1920.

SOUTH-WEST ENGLAND AND SOUTH WALES.

NATURAL GAS IN NORTH WALES.—References in the annual report of the Gas Council to the acceleration of research into the experimental use of methane gas (fire damp) drained from a mine in North Wales have been expanded by Mr. T. Mervyn Jones, chairman of the Wales Gas Board at a Press conference. The experiments, which have begun at Point of Ayr Colliery, North Wales, he described as the first major scheme of its kind in the United Kingdom, and added that a national body of scientists was working on the project. Methane would be sought from other mines in North Wales. House gas originating from the Point of Ayr colliery would be available by 1955. About 600,000 cub. ft. of gas a day would be available, which was expected to save about 25,000 tons of coal a year. Because of new sources of supply in North Wales, added Mr. Jones, it was now certain that a gas grid would be provided there. The cost of the new grid and the extended South Wales grid was estimated to be 5,000,000*l.*

SOUTH WALES INSTITUTE OF ENGINEERS.—Professor W. R. D. Jones, head of the Department of Metallurgy at University College, Cardiff, has been installed President of the South Wales Institute of Engineers in succession to Mr. John Griffiths. Appointed to the staff of the Department of Metallurgy, Cardiff, in 1919, he became professor in 1933. He has assisted in the growth of the department to help meet the requirements of industry, and has always tried to foster a close relationship between local industries and the applied-science department of the University.

WAGES AND CONDITIONS AT COKE-OVEN PLANTS.—Men employed at six coke-oven plants in South Wales, who had threatened to strike over claims in respect of wages and conditions, have withdrawn their notices. Originally 1,200 notices were handed in from the Caerphilly, Bargoed, Nantgarw, Aberdare, Bedwas and Coed Ely lodges of the National Union of Mineworkers coke-oven employees. The men had been demanding time and a fifth for afternoon and night shifts, subsidised transport, and an eight-hour shift, inclusive of meal times. These demands are to be considered for all coke employees in Britain at a meeting of the national negotiating body for the coke and by-product industry in London.

SWANSEA MINERS AND SATURDAY WORK.—A delegate meeting of miners in the Swansea area passed a resolution asking the executive council of the South Wales area of the National Union of Mineworkers to call a coalfield conference to consider the immediate cessation of all Saturday working. The decision was in protest against the refusal of the National Coal Board to meet the wage demands of lower-paid employees in the industry.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

INSTITUTION OF THE RUBBER INDUSTRY.—*Midland Section:* Monday, November 9, 5 p.m., James Watt Memorial Institute, Birmingham. (i) "Influence of Organic Chemicals in Rubber Manufacture," by Mr. F. A. Jones; and (ii) "Methods of Controlling Quality of Results in a Compounding Laboratory," by Mr. B. J. A. Martin.

CHEMICAL SOCIETY.—*South Wales Branch:* Monday, November 9, 5.30 p.m., Chemistry Department, University College, Cardiff. "Molecular Re-Arrangements," by Professor M. J. S. Dewar. *Newcastle and Durham Branch:* Friday, November 13, 5.30 p.m., King's College, Newcastle-upon-Tyne. "The Third Dimension in Chemistry," by Dr. A. F. Wells.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Education Discussion Circle:* Monday, November 9, 6 p.m., Savoy-place, Victoria-embankment, W.C.2. Discussion on "The Requirements of Electrical Engineering Textbooks," opened by Instructor Commander D. K. McCleery. *North-Eastern Centre:* Monday, November 9, 6.15 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "An Assessment of the Impregnated Pressure Cable," by Dr. L. G. Brazier, Mr. D. T. Hollingsworth and Dr. A. L. Williams. *London Students' Section:* Tuesday, November 10, 7 p.m., R.E.M.E. Depot, Arborfield, Berkshire. "Scanning Generators," by Lieutenants M. J. Wyatt and P. D. Gibbons. *Radio Section:* Wednesday, November 11, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. "The Design of Very-High-Frequency Mobile Radio Systems," by Mr. E. P. Fairbairn. *Institution:* Thursday, November 12, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Discussion on "Safety Precautions in Electronic Apparatus, with Particular Reference to Medical Applications," opened by Mr. H. W. Swann and Mr. H. W. Shipton.

INSTITUTE OF PACKAGING.—*Northern Area:* Monday, November 9, 6.30 p.m., Exchange Hotel, Liverpool. Discussion on "Export Shipments."

INSTITUTE OF METALS.—*Scottish Local Section:* Monday, November 9, 6.30 p.m., 39, Elmbank-crescent, Glasgow. "Gas Unsoundness," by Dr. C. E. Ransley.

INSTITUTE OF FUEL.—*North-Eastern Section:* Monday, November 9, 6.30 p.m., King's College, Newcastle-upon-Tyne. "Waste-Heat Recovery by Turbines," by Mr. G. L. Duffett.

INSTITUTION OF WORKS MANAGERS.—*Manchester Branch:* Monday, November 9, 6.45 p.m., Grand Hotel, Manchester. "Producing and Selling," by Mr. C. Starkey and Mr. R. S. Symond. *Birmingham Branch:* Tuesday, November 10, 7 p.m., Grand Hotel, Birmingham. "Material Handling for Large and Small Factories," by Mr. L. Landon Goodman. *Doncaster Branch:* Thursday, November 12, 7 p.m., Danum Hotel, Doncaster. "The Failures of Time Study," by Mr. A. Usalis.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Central London Branch:* Monday, November 9, 7 p.m., St. Ermin's Hotel, Caxton-street, S.W.1. "Progress of the British Electricity Authority," by Mr. M. A. H. Clements. *York Branch:* Wednesday, November 11, 7.30 p.m., City Hotel, Lendal, York. "Cold-Cathode Lighting," by Mr. J. M. Stanford. *Bradford Branch:* Wednesday, November 11, 7.30 p.m., Midland Hotel, Bradford. Film Evening. *Stoke and Crewe Branch:* Friday, November 13, 7.30 p.m, Copeland Arms Hotel, Stoke-on-Trent. "Applications of Pyrotenax," by Mr. H. J. Hansen.

JUNIOR INSTITUTION OF ENGINEERS.—*Sheffield Section:* Monday, November 9, 7.30 p.m., Livesey Clegg House, Union-street, Sheffield. Presidential Address on "Engineering Aspects of Water Supply," by Mr. P. J. Noel Wood. *Institution:* Friday, November 13, 7 p.m., Townsend House, Greycoat-place, Westminster, S.W.1. "Post-War Ship Design and the Future," by Mr. C. A. Hobson.

INCORPORATED PLANT ENGINEERS.—*Dundee Branch:* Monday, November 9, 7.30 p.m., Mathers Hotel, Dundee. "Hydraulics as Applied to Machine Tools," by Mr. T. Ransome. *Manchester Branch:* Tuesday, November 10, 7.15 p.m., Engineers' Club, Manchester. Discussion on "Illumination and Factory Lighting." *East Midlands Branch:* Wednesday, November 11, 7 p.m., Offices of the East Midlands Gas Board, Parliament-street, Nottingham. "Cost and Works Accounting for the Works Engineer," by Mr. S. H. Alloway. *North-East Branch:* Thursday, November 12, 7 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "Manufacture of Ball Bearings," by Mr. L. B. Jack.

CHEMICAL ENGINEERING GROUP.—Tuesday, November 10, 5.30 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. "The Application of Impulse Rendering to the Animal Fat Industry," by Mr. I. H. Chayen and Mr. D. R. Ashworth.

INSTITUTION OF CIVIL ENGINEERS.—*Public Health Engineering Division:* Tuesday, November 10, 5.30 p.m., Great George-street, S.W.1. "Atmospheric Pollution: Causes, Effects and Prevention," by Dr. Albert Parker. *Midlands Association:* Thursday, November 12, 6 p.m., James Watt Memorial Institute, Birmingham. "Experimental Structural Research and Design Methods," by Dr. A. J. S. Pippard.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, November 10, 5.30 p.m., 85, The Minories, E.C.3. "The Resistance to Failure of Condenser and Heat Exchanger Tubes in Marine Service," by Dr. P. T. Gilbert.

INSTITUTION OF MECHANICAL ENGINEERS.—*Automobile Division:* Tuesday, November 10, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Problems in the Design and Development of an Economical Automobile Gearbox," by Mr. T. C. F. Stott. *North-Eastern Branch:* Thursday, November 12, 6.30 p.m., Gas Showrooms, 27, Norton-road, Stockton-on-Tees. "Contemporary Methods of Watch Production," by Mr. R. A. Fell and Mr. P. Indermuhle. *Institution (Steam Group):* Friday, November 13, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "The Synthesis of Two Marine Water-Tube Boilers," by Commander (E) L. Baker.

ILLUMINATING ENGINEERING SOCIETY.—Tuesday, November 10, 6 p.m., The Welcome Research Institute, Euston-road, N.W.1. "Application of Fluorescent Dimming Circuits," by H. H. Ballin and Mr. W. J. Vine.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Midland Counties Branch:* Tuesday, November 10, 7 p.m., The King's Hall, Queen-street, Derby. "Tubular Structures," by Mr. E. McMinn. *Institution:* Thursday, November 12, 6 p.m., 11, Upper Belgrave-street, S.W.1. Joint Meeting with the BRITISH SECTION OF THE SOCIÉTÉ DES INGÉNIEURS CIVILS DE FRANCE. "Different Types of Wharves and Maritime Structures Recently Executed in France," by Mr. L. P. Brice.

INSTITUTION OF PRODUCTION ENGINEERS.—*Birmingham Graduate Section:* Tuesday, November 10, 7 p.m., James Watt Memorial Institute, Birmingham. "Human Aspect in Production Planning and Control," by Mr. B. G. L. Jackman. *Southern Section:* Wednesday, November 11, 7 p.m., Municipal College Annexe, Portsmouth. "Practical Application of Tungsten," by Mr. F. H. Bates. *Preston Section:* Wednesday, November 11, 7.15 p.m., Victoria and Station Hotel, Preston. "Use of Automatic Lathes," by Mr. H. R. Adcock. *Coventry Section:* Thursday, November 12, 7 p.m., Geisha Café, Hertford-street, Coventry. "Activities of P.E.R.A.," by Dr. D. F. Galloway. *Leicester Section:* Thursday, November 12, 7 p.m., Bell Hotel, Leicester. "Managements' Responsibility for Production," by Mr. B. H. Dyson.

LIVERPOOL METALLURGICAL SOCIETY.—Tuesday, November 10, 7.15 p.m., College of Technology, Liverpool. "Metallic Arc Welding and Electrodes During the Past Half-Century," by Mr. E. Flintham.

INSTITUTE OF PETROLEUM.—Wednesday, November 11, 5.30 p.m., 26, Portland-place, W.1. "Paint in the Petroleum Industry," by Dr. H. B. Footner.

LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 11, 6 p.m., 24, Dale-street, Liverpool. "Modern Practice in Cathodic Protection," by Mr. G. McHardy and Mr. H. M. Powell.

INSTITUTION OF CHEMICAL ENGINEERS.—*Midlands Branch:* Wednesday, November 11, 6.30 p.m., The University, Edmund-street, Birmingham. "Perforated Plates in Liquid-Liquid Extraction," by Mr. F. H. Garner, Mr. S. R. M. Ellis and Mr. D. W. Fosbury.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Wednesday, November 11, 6.30 p.m., London School of Hygiene, Keppel-street, W.C.1. "A High-Definition General-Purpose Radar," by Mr. J. W. Jenkins and others.

INSTITUTE OF BRITISH FOUNDRYMEN.—*London Branch:* Wednesday, November 11, 7.30 p.m., Waldorf Hotel, Aldwych, W.C.2. "Pattern Making and Storage," by Mr. A. Talbot.

NEWCOMEN SOCIETY.—Wednesday, November 11, 7.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. Annual Meeting. Presidential Address by Mr. J. Foster Petrie.

ROYAL SOCIETY.—Thursday, November 12, 4.30 p.m., Burlington House, Piccadilly, W.1. "Research Department of Courtaulds Ltd.," by Mr. A. H. Wilson, F.R.S.

ENGINEERS' GUILD.—*Metropolitan Branch:* Thursday, November 12, 6 p.m., Caxton Hall, Victoria-street, S.W.1. "The Engineers' Guild: Its Purpose and Value," by Mr. Henry Nimmo and Mr. G. E. M. Godfrey.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday November 13, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Propeller Cavitation," by Professor L. C. Burrill and Mr. Arnold Emerson.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, November 13, 6.45 p.m., Engineers' Club, Manchester. "Application of Reinforced Concrete to Industrial Buildings," by Mr. M. B. Watson.

PERSONAL.

DR. W. ABBOTT, C.M.G., O.B.E., M.I.Mech.E., has retired from the position of Staff Inspector of Engineering to the Ministry of Education. He will continue to advise on the Athlone Fellowship Scheme, and he will assist the Federation of British Industries as director of studies with their overseas scholarship scheme.

MR. F. H. ROLT, O.B.E., B.Sc., M.I.Mech.E., M.I.Prod.E., who until his retirement on November 1 was Superintendent of the Metrology Division of the National Physical Laboratory, has now accepted the position of consultant in metrology to the Coventry Gauge & Tool Co. Ltd., Taylor, Taylor & Hobson Ltd., Hilger & Watts Ltd., and the Brooke Tool Manufacturing Co. Ltd.

THE RT. HON. THE EARL OF DUDLEY, M.C., T.D., D.L., J.P., has retired from the board of the British Iron and Steel Corporation Limited, of which he had been chairman since its inception in 1935, following the purchase of the Round Oak Steel Works Ltd., by Tube Investments Ltd. SIR CHARLES BRUCE-GARDNER, Bt., M.I.Mech.E., has been elected chairman of the board.

MR. STANLEY BARR, general manager, Union-Castle Mail Steamship Co., Ltd., 3, Fenchurch-street, London, E.C.3, has been made a director to fill the vacancy caused by the death of the DUKE OF ABERCORN.

SIR ARCHIBALD J. BOYD is retiring from his position of managing director, Metropolitan-Cammell Carriage and Wagon Co. Ltd., Metropolitan-road, Saltley, Birmingham, 8, on December 31, and will be succeeded by MR. H. N. EDWARDS, assistant managing director. MR. A. T. CHEESLEY, director and production general manager, is also retiring on December 31 and will be succeeded by MR. NORMAN HADDON.

REAR-ADMIRAL (E) G. C. ROSS, C.B., C.B.E., who, as stated on page 335, *ante*, retired from the position of Director, aircraft maintenance and repair, Admiralty, on October 5, has joined Armstrong Siddeley Motors Ltd., Coventry, as liaison officer between the Admiralty and this firm.

DR. R. O. JONES has been appointed the first resident liaison officer of the Department of Scientific and Industrial Research in Wales. His office is at the Welsh Board of Health Building, Cathays Park, Cardiff. (Telephone: Cardiff 5120.)

MR. J. M. ORMSTON, C.B.E., M.I.N.A., who retired from the position of director and general manager of the Walker-on-Tyne Naval Shipbuilding Yard of Vickers-Armstrongs Ltd., on October 1, 1950, has been elected managing director of S. P. Austin and Son, Ltd., Sunderland. He became a director of this firm in November, 1952.

COL. F. A. NEILL, chairman and managing director of James Neill & Co. (Sheffield), Ltd., Sheffield, has been elected chairman of the East and West Ridings Region of the Federation of British Industries.

MR. C. F. MERRIAM, chairman of the British Xylonite Co., has been elected President of the British Plastics Federation.

MR. F. SHORT, Index Works, Curran-road, Cardiff, (Telephone: Cardiff 24111), has been appointed small-tools representative, in South Wales, for Burton, Griffiths & Co., Ltd., Birmingham.

MR. L. J. DENNETT has been appointed general manager of the Canadian associated company of Decca Radar Ltd., namely, Decca Radar (Canada) Ltd.

MR. J. HOLMES, formerly export manager of Thos. W. Ward Ltd., Sheffield, has been appointed sales manager of Thos. Storey (Engineers) Ltd., Stockport.

WESTOOL LTD., St. Helen's Auckland, Bishop Auckland, County Durham, are now manufacturing Warner electro-magnetic brakes and clutches under licence from the WARNER ELECTRIC BRAKE AND CLUTCH CO., Beloit, Wisconsin, U.S.A.

VACU-BLAST, LTD., manufacturers of portable shot-blast equipment, have formed a subsidiary company, VACU-BLAST CONTRACTORS LTD., 291, Aberdeen-avenue, Slough, Buckinghamshire, which offers a shot-blasting service on a contract basis.

The address of the United Kingdom office of the DEPARTMENT OF LABOUR OF THE GOVERNMENT OF CANADA is 61, Green-street, London, W.1. (Telephone: MAYfair 9331-7.)

WICKMAN LTD., Coventry, have concluded a sole selling-agency agreement with EDOUARD DUBIED ET CIE., Neuchâtel, Switzerland.

MACROME LTD., Aldersley, Wolverhampton, have been appointed exclusive sales managers for the hand-tool division of the BREN MANUFACTURING CO. LTD., Gateshead, 11.

SHELL TANKERS LTD., a new company, has been formed to deal with the management and operation of the fleet of the ANGLO-SAXON PETROLEUM CO., LTD.

As from January 1, 1954, the offices of the BRITISH ELECTRICAL POWER CONVENTION will be removed from 16, Stratford-place, to Winsley-street, London, W.1.

THE INTERNATIONAL MOTOR SHOW, EARL'S COURT.

(*For Description, see Page* 587.)

FIG. 27. RILEY "PATHFINDER" SALOON CAR.

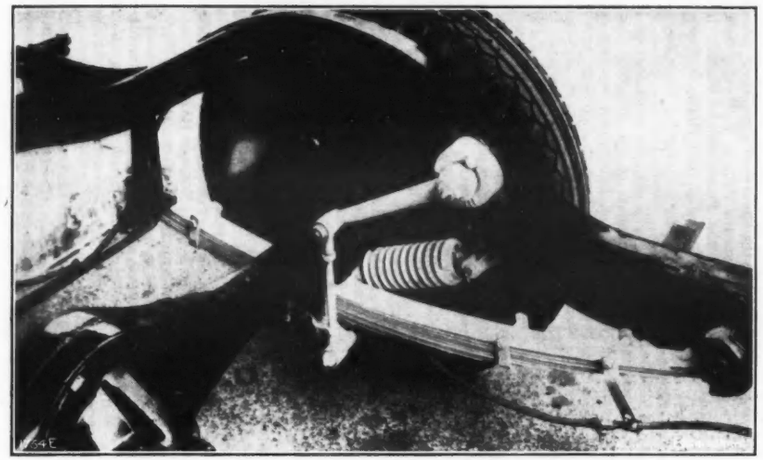

FIG. 28. GRÉGOIRE TENSION SPRING IN REAR SUSPENSION.

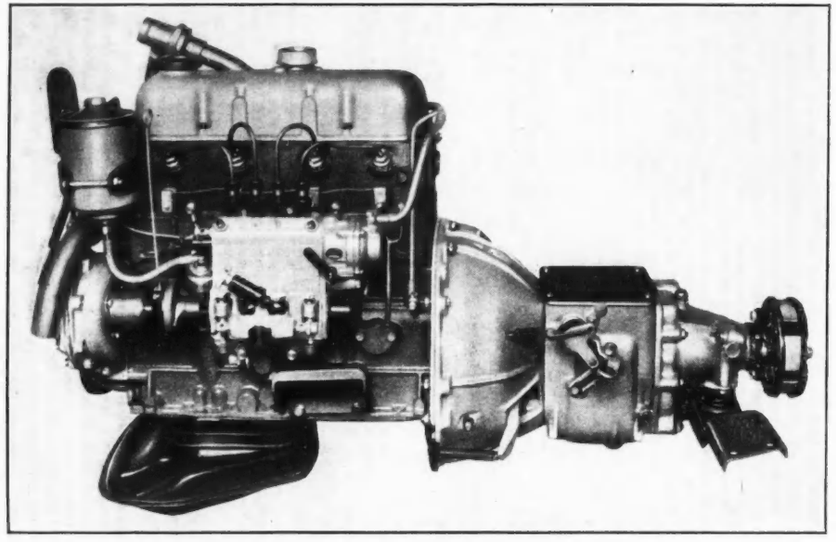

FIG. 29. FIAT DIESEL ENGINE FOR MOTOR-CARS.

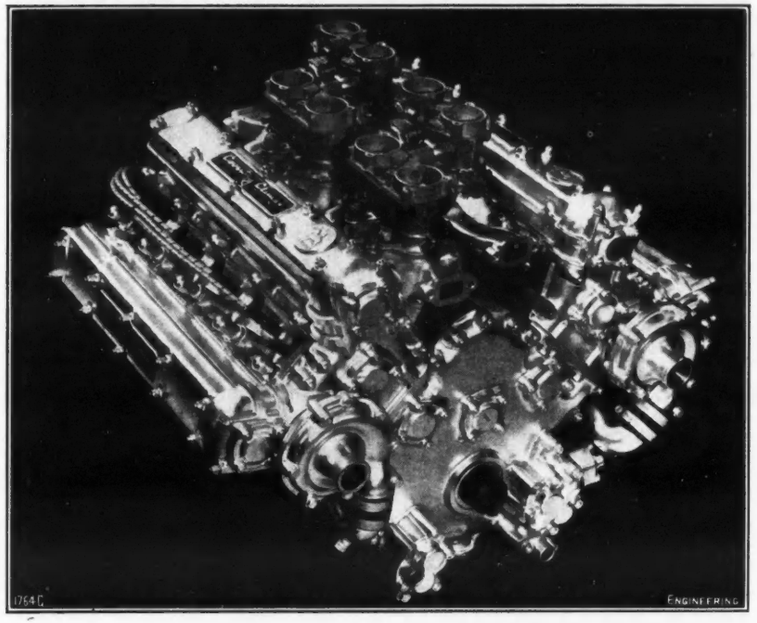

FIG. 30. COVENTRY CLIMAX V-8 ENGINE.

ENGINEERING

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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TEMple bar 3663 and 3664.

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For Canada	£5 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, NOVEMBER 6, 1953.

VOL. 176. No. 4580.

ATOMIC POWER STATIONS.

SOME of the British engineering firms now working as contractors and sub-contractors for steam and hydro-electric power-station construction will be engaged on atomic power stations within the next few years. The secrecy surrounding atomic-energy research will be broken sufficiently for industry to come to grips with the practical problems of producing electricity for the national grid from this power which pure science has released. A chain-reaction (of another kind) is in prospect: the impetus behind this commercial development, originating at Harwell, will be transmitted from one firm to another, from one brain to another, until a complex pattern of responsibility and initiative has been created.

Such patterns in industry—partly planned, partly growing in unexpected ways—have produced the finest works of engineering in the past. The aircraft industry, especially, owes much to State "patronage," but it has more than justified the expense by contributing its own lively enthusiasm and approach. Atomic-power stations will no doubt be developed by similar methods. Sir Christopher Hinton, who is head of the Atomic Energy Production Establishment at Risley, addressed an audience in New York, on October 30, on "Atomic Energy Developments in Great Britain." He said that his staff have recently started to construct a thermal reactor from which power will be produced in industrial quantities, and they expect shortly to be building a fast reactor. "We hope," he said, "that we shall be generating electrical power which will be pumped into the grid system of the country within the next few years, and we believe it will then be possible to suggest to the British Electricity Authority that they should build additional reactors of this [thermal] type, having them designed and constructed by the power-plant industry of the country." Those firms which take part in the work will indeed be fortunate. No one can foretell the ultimate developments of this industrial race in which they will take the lead.

It is a credit to the British atomic-energy organisation that, so soon after the war, they have reached this advanced stage in the peaceful application of their science. Much of the early, fundamental work was done in Britain, and even before 1943 there had been some study of its industrial possibilities. But in that year it was agreed, between the leaders of the two countries, that the whole of the research and production work for the atomic bomb should be carried out in the United States. Thus America gained a lead of three years of intensive war-time progress—a lead which Sir Christopher regards as equivalent to about six years under post-war conditions. In 1946, when the British atomic-energy organisation was set up, the engineering industry was fully occupied, particularly in regaining their export trade. While the United States were able to entrust much of their atomic-energy development work to various commercial agencies, with policy and the broad plan of operations directed by the national Atomic Energy Commission, the British state organisation, inevitably, has had to undertake most of the research and virtually all the design, construction and operation.

Sir Christopher remarked that the disadvantage of this organisation is that it has thrown a very heavy load on the senior members of the staff (he has been head of his department since it was founded in 1946). Doubtless, when industry is invited to participate in the commercial developments, there will have to be a reshuffle of the staff to ensure that the right brains are in the right places. There has also been an advantage, he said, in that the British organisation is closely co-ordinated, with every branch well aware of the work proceeding in other departments. It has been economical in its use of staff and it has achieved results which would have demanded a greater effort had the work been dispersed. In three or four years time, the national organisation will continue with the pioneering work for atomic energy, and, having pioneered developments, will hand them out to industry for manufacture on a wider scale. Industrial firms will be expected to make the further developments which always become possible with growing operational experience.

The review which Sir Christopher presented covered the major advances since 1946. At Harwell, an organisation has been built up, under Sir John Cockcroft, which is engaged in long-term research and in devising the processes which are to be used in industrial factories. It also undertakes a considerable amount of applied research in aid of these industrial processes, but Sir Christopher's Production Division has a research and development section which does most of the chemical engineering and other development work required for translating Harwell flow-sheets into industrial designs. Thus, the Production Division designed and constructed the large Harwell experimental pile which was put into operation early in 1948. It has built a factory at Springfields for the conversion of uranium ore into canned uranium metal slugs. Originally the intention was to build water-cooled graphite-moderated piles, but like all piles in which the coolant has a neutron absorption

capacity which outweighs its effect as a moderator, it is possible for them to explode and scatter dangerous fission products over the countryside. It was therefore decided to build air-cooled graphite-moderated piles for the production of plutonium, since they are inherently safe. At the Springfields factory there are also chemical plants for the extraction of plutonium and uranium from the irradiated metal. The pilot-plant stage was omitted in this work. This was a bold experiment which Sir Christopher says was fully justified by the successful results. Indeed, he stressed particularly that the construction of pilot plants is not an unmixed blessing; it is sometimes better to face the designer with the complete challenge of the finished design at the outset.

Other work carried out has included the construction of a gaseous diffusion plant for the manufacture of uranium slightly enriched in the fissionable 235 isotope. This plant, which started operation at Capenhurst early this year, was necessary for re-enrichment of the purified uranium separated from the irradiated slugs in the chemical plant at Windscale and made available for re-cycling through the piles. Another plant, alongside it, is also being constructed for the manufacture of highly enriched uranium. The power-producing reactor already referred to is graphite-moderated and is cooled by circulating carbon dioxide under pressure. The reactor core is enclosed in a mild-steel shell within the biological shield, and the boilers are arranged around it, supplying steam to turbo-alternators of conventional design.

The urgency of developing the industrial application of atomic energy is greater, Sir Christopher considers, in Great Britain than in the United States, because of the diminishing supplies of easily worked coal. He estimates that it should be possible to generate electricity from gas-cooled thermal reactors at a price which is not greatly in excess of the cost of generation in a modern power station. Also, the cost of generation from nuclear energy is likely to fall. He visualises three stages of development. The first is the construction of a series of thermal reactors which both generate power and produce fissile material. In the second, the fissile material is used as fuel in fast reactors; power will then be generated by thermal reactors and fast reactors running side by side. Finally, when the stock of fissile material is sufficient, it should be possible to discontinue the use of thermal reactors and to rely only on the fast reactors, which should breed at least enough new fissile material to make them self-supporting. He concluded his address with a plea to the United States authorities to conduct a practical test in which a reactor is allowed to become "super-critical," so that it "runs away." At present no one has had practical experience of what happens in these conditions. It would be valuable to know the results of such an experiment, which could well be carried out in one of the extensive thinly-populated areas of the United States.

The United States Atomic Energy Commission released details of their power plans last month. Mr. Thomas E. Murray said that the Commission has embarked on the construction of a power reactor which will develop at least 60 MW. Because of the Westinghouse company's experience with the reactor system chosen, that firm has been appointed the principal contractor. The Commission are inviting offers from industry to invest risk capital in the building of the steam and turbine portions, as well as in the operation of the entire plant. Mr. Murray emphasised the importance of enlisting "the cost-cutting drives, the know-how, skills and competition of many segments of business and industry." The same view appears to be held in this country. There will be plenty of hard work on both sides of the Atlantic and the next decade will be full of interest.

NOTES.

MILLSPAUGH CENTRIFUGAL PIPE FOUNDRY, SHEFFIELD.

A FOUNDRY for the production of bronze and other non-ferrous metal pipes of large diameter by a centrifugal casting process was officially opened by the Lord Mayor of Sheffield, Councillor Oliver S. Holmes, F.C.A., J.P., on October 28 at the works of Millspaugh Limited, Alsing-road, Sheffield, 9. The private company of Millspaugh Limited was founded in this country in 1933 by Mr. W. H. Millspaugh, who had previously developed a centrifugal casting process for the manufacture of non-ferrous metal pipes in the United States. Accommodation for the new firm was found close to the East Hecla works of Hadfields Limited, Sheffield. At the end of the late war the firm became a subsidiary company of Hadfields Limited, but in February, 1951, Millspaugh Limited were "hived off" from the parent company. A new administration block was constructed at Alsing-road and when, in June, 1952, Hadfields vacated their old forge, the site became available for a new Millspaugh foundry. This building, which has been equipped to produce centrifugal castings ranging from 5 in. in outside diameter by 10 ft. in length to 60 in. in outside diameter by 31 ft. in length, was that opened on Wednesday of last week. The plant installed includes, in addition to the rotary casting machines, a sand-preparation plant, ramming pit, oil-fired recirculation system mould-drying stove, a battery of four oil-fired rotary tilting furnaces for metal melting and a vibratory knock-out machine. The bronze and other non-ferrous metal cylinders produced are for rolls for the papermaking industry and are also for propeller-shaft liners, bushings, pump liners, hydraulic-press liners, pump barrels, and shaft liners and sleeves for the marine engineering and general engineering industries. At a luncheon which followed the opening ceremony, Mr. J. B. Thomas, chairman of the company, gave an outline of the history and progress of the firm. The toast of "The New Foundry" was proposed by the Lord Mayor and briefly replied to by Mr. E. Ayres, the foundry manager. The toast of the guests was proposed by Mr. R. C. Heys, M.I.Mech.E., managing director of the company, and the response was by Mr. A. Roebuck, President of the Institution of Mechanical Engineers.

THE ELECTRICAL INDUSTRY AND THE EXPORT TRADE.

The position regarding exports of British electrical equipment in the near future, as disclosed by Mr. D. Maxwell Buist, export director of the British Electrical and Allied Manufacturers Association, at a Press conference on Wednesday, October 28, is not one which can be viewed with any great satisfaction, and will demand considerable effort to correct it. In broad outline, the value of these exports fell from 149*l.* million during the first eight months of 1952 to 141*l.* million during the corresponding period of the present year, a decrease of about 5 per cent. This decrease, it is true, was largely due to five items of lighter equipment, though motors also showed a reduction. On the other hand, the value of the turbines exported increased by 1·7*l.* million, but new orders during the first nine months of the year amounted only to 70 MW compared with 300 MW in 1952 and 550 MW three years ago. Nevertheless, as Mr. Buist pointed out, the industry was exporting about 40 per cent. of its production and in so doing had reached "the economic limit." To increase exports further it would be necessary to develop the home trade and to do this he suggested that present restrictions on capital investment and hire purchase should be removed and that the purchase tax should be abandoned. An obvious reason for the falling off in export markets was increased competition, and Russia and China, which used to be good customers, were now imposing restrictions. British firms were also handicapped by being unable to offer such favourable credit terms as France, Germany and Holland could do, and on this point the Federation of British Industries had had discussions with organisations abroad. Ways and means of helping British firms to obtain more contracts for large generation schemes were also to be discussed with the World Bank. While, therefore, nothing like a slump is in prospect, it is obvious that active steps must be taken to remove the many obstacles which impede development.

INSTITUTE OF WELDING ANNUAL DINNER.

The annual dinner of the Institute of Welding was held at the Park Lane Hotel on Wednesday, October 28. The president of the Institute, Mr. A. R. Jenkins, M.I.Mech.E., was in the chair and the chief guests were the Right Honourable Viscount Runciman, Sir Frederick Handley Page and the Mayor of Westminster, Alderman C. P. Russell. The chairman expressed regret that H.R.H. The Duke of Edinburgh had not been able to be present but showed great appreciation of the fact that His Royal Highness had accepted honorary membership of the Institute. In proposing the toast of the Institute, Lord Runciman drew attention to the keen competition which now exists in the marine field. He urged that all possible means should be used to speed and improve the production of ships and mentioned the steady advances made in welding techniques. Mr. Jenkins, in his reply, said that although their 5,000 members were spread over 19 branches in this country, they intended to act as a national institute and not as a federation of local associations. They hoped to start publication of a journal in the new year and he invited papers to be submitted. A handbook was also being prepared. He asked that welding should be included as a part of the ordinary college course, as riveting already was. Mr. R. G. Braithwaite proposed "The Guests" and in his reply, Sir Frederick Handley Page drew attention to the Insignia Awards of the City and Guilds of London Institute which are given after practical proficiency has been attained.

THE LIVERPOOL ENGINEERING SOCIETY: PRESIDENTIAL ADDRESS.

In his presidential address, delivered before the Liverpool Engineering Society on October 14, Mr. Vernon L. Farthing, M.I.Mech.E., M.I.Mar.E., covered numerous subjects of academical and practical interest to the engineer. In regard to expenditure on research, he said that although British industry was nowadays spending more on research and development than heretofore, we still lagged far behind the United States in this matter, and he queried whether the apparent failure of this country "to keep in the forefront of commercial application of our fundamental research during the last two decades" was the result of undue specialisation, or, due to a lack of technologists to apply basic principles to practical use. The need for specialisation, however, was agreed, as only by such methods could we progress quickly in a particular sphere, while engineering was becoming so complex, the individual could "not hope to be *au fait* with all up-to-date developments." Touching upon productivity, he said that in the United States about two and a half times as much capital per employee was used than in this country, and that although there was a disinclination on the part of some employees to utilise the aids of mechanisation, some of the trades union leaders had accepted the fact that increased production was essential if this country were to pay its way, be able to compete in export markets and maintain the standard of living. He felt there was a need to publicise both the technological achievements of the engineering industry and the vital part it played in world development, and among recently publicised achievements he quoted the melting of metals suspended in space by electromagnetic forces in order to obtain extreme purity for research purposes, and also the achievements of the petroleum industry, which had made Britain the largest oil-refining country in Western Europe, with a capacity of 27·8 million metric tons a year, and was now exporting petroleum products to a greater annual value than that of our coal exports. He concluded his address with observations on the purpose of engineering and in support of his advocacy of publicity, he quoted from the March, 1952, issue of the *Chartered Civil Engineer*,

ELECTRONICALLY-CONTROLLED PAPER MACHINE.

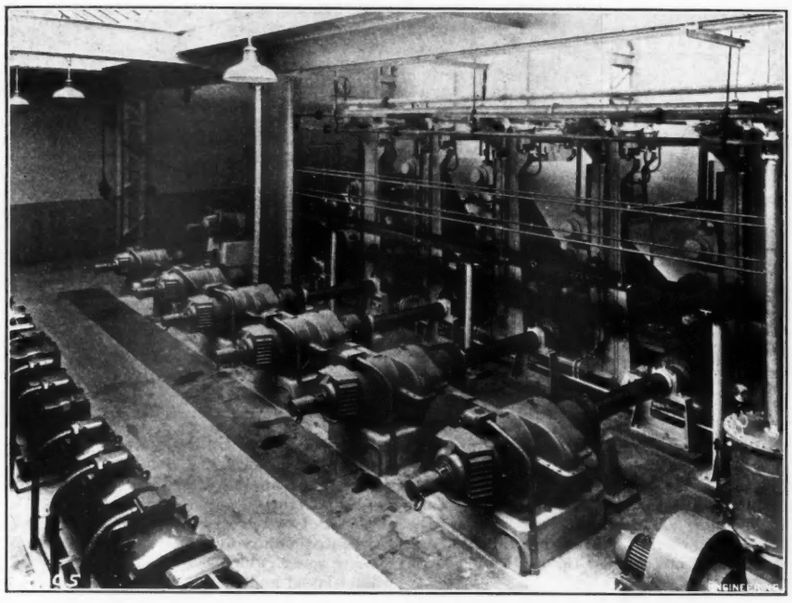
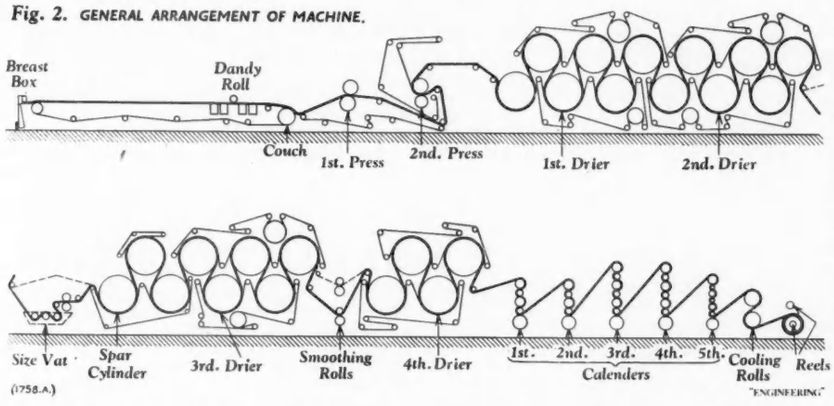


FIG. 1. GEARED MOTOR UNITS DRIVING CALENDERS.

Fig. 2. GENERAL ARRANGEMENT OF MACHINE.



the journal of the Institution of Civil Engineers, which records "The Council of the Institution is of the opinion that the public should be made better acquainted with the work done by engineers and feels that much can be done by engineers themselves to bring this about."

FARADAY HOUSE OLD STUDENTS ASSOCIATION.

The annual dinner of the Faraday House Old Students Association was held at the Savoy Hotel, London, on Thursday, October 29, the President (Mr. A. N. Irens) being in the chair. Proposing the toast of "Faraday House," the President of the Institution of Electrical Engineers (Mr. H. Bishop) said that that body was now in its 64th year and had a proved record of achievement, which was a tribute to the "sandwich" system of training. It was, however, fair to inquire whether this system was adequate to present day conditions and it was significant that Faraday House was about to modify their syllabus to comply with the new examination regulations of the Institution. This would involve a re-assessment of the practical part of the Faraday House course. Mr. Bishop went on to stress the need for higher technological education, in the organisation of which, however, we should adopt the methods which were most suitable for our own needs. The right type of students was not entering the universities in sufficient numbers, and that must be corrected. One way of doing this was for engineers to abandon their national reticence and publicise their work. In reply, the Principal of Faraday House, (Dr. W. R. C. Coode-Adams) said that to comply with the new Institution regulations Faraday House was adopting a full three years academic course, the idea being to provide increased fundamental knowledge. It was significant that engineering physics, in other words nuclear physics, was now one of the subjects for examination. He felt that with an increase in the standard fewer candidates would pass and that they would therefore run into an impasse. In fact, there was already a serious shortage of science teachers; and it had been suggested that to relieve this the standard would have to be lowered. Another trouble was that the universities, instead of providing fundamental knowledge and leaving practical experience to be obtained elsewhere, were now doing the reverse—a curious inversion. In reply to the toast of "The Guests," which was proposed by Mr. D. E. Bird, Air Chief Marshal Sir John Whitworth Jones called attention to the absolute dependence of the fighting services on the electrical engineering profession. Even greater demands would be made upon their skill in future, but it was essential in inventing apparatus to strengthen our defences care should be taken to provide for its maintenance by semi-skilled personnel. It was also necessary to provide for a balance between the supply of the apparatus itself and the essential spares and test equipment.

PAPER-MAKING MACHINE WITH ELECTRONIC CONTROL.

THE Guard Bridge Paper Company, Limited, near St. Andrews, was established in 1872 for the manufacture of finished paper. The mill, built for this purpose, stands on the bank of the River Eden and had originally a weekly output of 15 to 18 tons, the raw material being wood pulp. During the next 20 years a change was made to the production of high quality printing paper from esparto grass, and by 1889 three machines with a total weekly output of 125 tons were in operation. Later two other machines were added until the annual output had risen to 12,500 tons. It was then decided to replace the existing machines by one of the most modern design with an electronically-controlled sectional drive.

This machine, which was constructed by James Bertram and Son, Limited, Leith Walk, Edinburgh, and designed for the production of the highest quality papers, consists of tile-lined stock chests which are fitted with Bell's agitators. Above these chests is a rotary save-all, in which the machine waste water and couch trimmings are dealt with. To ensure the cleanliness necessary in the manufacture of high quality paper a six-unit Vickery Dirtec system with Purifuge centrifugal separators has been installed. These are followed by drum strainers with stainless-steel drums and acid-resisting tile-lined vats. The breast box, which is also of stainless steel, is of the double-V type and is fitted with an adjustable deckle head and flexible slice for controlling the flow of the stock to the wire. The wire itself is 10 ft. 2 in. wide and 70 ft. 5 in. long, the rolls, both for the supporting table and underwire, being carried in labyrinth-sealed ball bearings. The shake motion is of the Leith Walk vertical type and the dandy roll, which if of the driven type, is, like the main drive, electronically controlled. Most of the components at the wet end are chromium-plated and Fescolised or are of stainless steel.

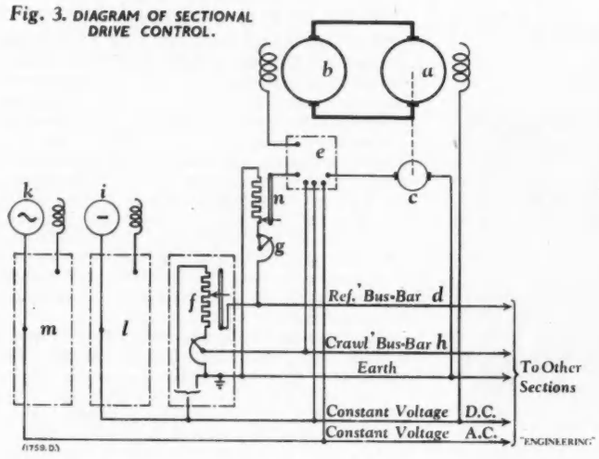
As will be seen from Fig. 2, the machine, which is of the Fourdrinier type and has a speed range of 40 to 400 ft. per minute, consists of a single box couch roll between which and the first press felt is an adjustable blow roll. The wet press section comprises two presses, the first of which is of the straight through suction type, while the second is a plain reversing press. The granite top rolls of these presses are mounted in rolls bearings, which are contained in spherical housings and are supported on cast-steel levers. These levers are equipped with double-acting air cylinders which both apply pressure and raise the rolls when it is necessary to change the felts. Both presses are fitted with Vickery oscillating doctors and felt conditioners. Between the second press and the driers is a continuous web weighing machine for indicating any variation in the substance of the sheet.

The drying cylinders, which come next in sequence, are 5 ft. in diameter and are fitted with collar oil bearing blocks, the pressure in which is controlled from a header tank. Both the dry and wet felt rolls are covered with vulcanite and run in ball bearings. The drying cylinders are of corrosion-resisting steel covered with felt and the vapour is extracted through the hollow section framing instead of by ducting. The hood, which consists of aluminium panels is carried on a steel framework. The paper then passes through a size bath and press and through three sparred drums, which are built up of cast-iron cylinders and longitudinal copper tubes, into a third drier, combined smoothing and damping rollers and a fourth drier. Finally, there are five stacks of calenders, each of which is fitted with pneumatic pressure equipment and motor operated gear for raising the rolls. All the rolls are provided with Vickery doctors, and Leith Walk doctors are fitted on the second and third stacks. At the end of the machine are two cast-bronze cooling rolls and a two-spindle reeler. The latter is driven by two separate electronically-controlled motors, as described in more detail below.

The necessary equipment for electrically driving and electronically controlling this machine has been supplied by the British Thomson-Houston Company,

ELECTRONICALLY-CONTROLLED PAPER-MAKING MACHINE.

Fig. 3. DIAGRAM OF SECTIONAL DRIVE CONTROL.



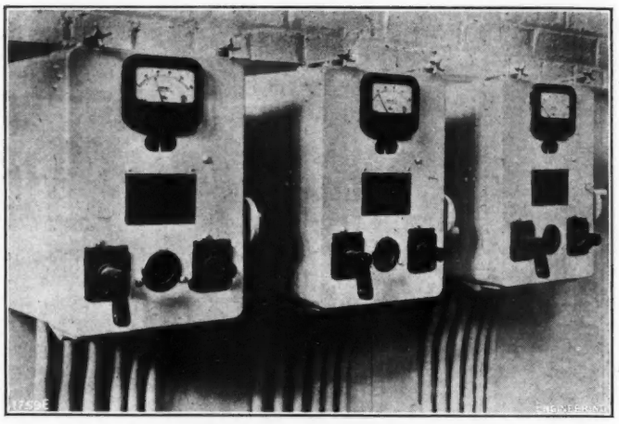


FIG. 4. GROUP OF SECTION CONTROL STATIONS.

Limited, Rugby. For driving purposes, the machine is divided into 17 sections at each of which power is applied by forced ventilated geared motor units as shown by the arrows in Fig. 2. The ratings of these motors and the gear ratios are set out in Table I, the second figure for horse-power being

TABLE I.—*Section Motor Ratings and Gear Ratios.*

Section.	Motor h.p.	Gear Ratios.
Couch	30/4·5	1,400/116
First press	15/2	1,400/122
Second press	15/2	1,400/68
First drier	20/3	1,400/77
Second drier	20/3	1,400/77
Size vat	10/1	1,400/93·5
Spar cylinder	15/2	1,400/75
Third drier	20/3	1,400/7·7
Smoothing roll	10/1	1,400/93
Fourth drier	15/2	1,400/75
First calender	30/4·5	1,400/69
Second calender	30/4·5	1,400/69
Third calender	30/4·5	1,400/69
Fourth calender	30/4·5	1,400/69
Fifth calender	20/3	1,400/83
Cooling roll	10/1	1,400/216
Reel	7·5/0·75	1,400/158

the rating at one tenth full speed. On certain sections, where journal bearings are used, extra torque capacity is provided at the lower end of the speed range. A photograph of the motors driving the calender section of the mill is reproduced in Fig. 1.

Each section motor is supplied from an individual generator, which forms part of a motor-generator set. These generators are conveniently grouped in sets as shown in Table II. This table also gives the

TABLE II.—*Generator Grouping.*

Motor Generator Set No. 1.	
Second press generator	12·5/2·7 kW
Second drier generator	17/3·5 kW
Couch generator	24/5 kW
Driving motor	125 h.p.
First drier generator	17/2·5 kW
First press generator	12·5/2·7 kW
Size vat generator	8·8/1·5 kW
Motor-Generator Set No. 2.	
Smoothing roll generator	8·8/1·5 kW
Spar cylinder generator	12·5/2·7 kW
First calender generator	24/5 kW
Driving motor	125 h.p.
Second calender generator	24/5 kW
Third drier generator	17/3·5 kW
Motor-Generator Set No. 3.	
Fifth calender generator	17/3·5 kW
Fourth calender generator	24/5 kW
Driving motor	125 h.p.
Third calender generator	24/5 kW
Fourth drier generator	12·5/2·7 kW
Cooling roll generator	8·8/1·5 kW
Exciter Set.	
Alternator	18 kW, 0·8 power factor, single phase.
Driving motor	46 h.p.
Exciter	9·5 kW

ratings of the various machines. The second figure is that obtainable at one tenth full voltage and was selected to cover low-speed and starting-torque requirements. The use of individual generators renders it possible to employ simple shunt-wound fixed-field motors, enables the different sections to be controlled, stopped and started individually, and makes it possible to simplify the contactor control gear.

A diagram of this multi-generator sectional drive is given in Fig. 3, in which the constantly excited direct-current motor is shown at *a*. The armature of this motor is supplied from the Ward Leonard generator *b* which is, in turn, excited by a grid controlled bi-phase thyratron *e*. A tachometer generator *c* is coupled to the motor and generates a voltage which is proportional to the speed of the section. This voltage is compared with the voltage of a reference 'bus-bar *d* and the difference is applied to an amplifier *e* which controls the firing of the thyratron. This amplification is high enough to allow the difference between the feed-back and tachometer voltages to be small. Owing to the absence of mechanical movements there is no inertia or wear and rapid response is achieved. The sensitivity is such that the speed change between the various sections due to all causes—including load and temperature fluctuations—is less than 0·1 per cent.

The reference 'bus-bar *d* is common to all sections and its voltage forms a link which rigidly ties their speeds together. The speed of the machine as a whole is adjusted by the motor-driven rheostat *f*, while that of one section relative to the others can be regulated by the rheostat *g*. This rheostat is mounted in the section-control station and modifies the reference voltage for that section. A low reference voltage for inching and running at crawl speed is obtainable from the crawl 'bus-bar *h*. An exciter *i* supplies the motor fields and contactor control gear, as well as direct current at 300 volts for the electronic regulators. The 480-volt alternator *k* supplies all the alternating current required by the electronic control equipment. Each of these machines is controlled by its own electronic-voltage regulator *l* and *m*, so that operation of the speed regulators is independent of variations in the supply frequency and voltage. A motor-operated starting rheostat *n* enables each section of the machine to be accelerated at a controlled rate by transferring the reference voltage for the speed regulator from the crawl 'bus-bars *h* to the reference 'bus-bars *d*.

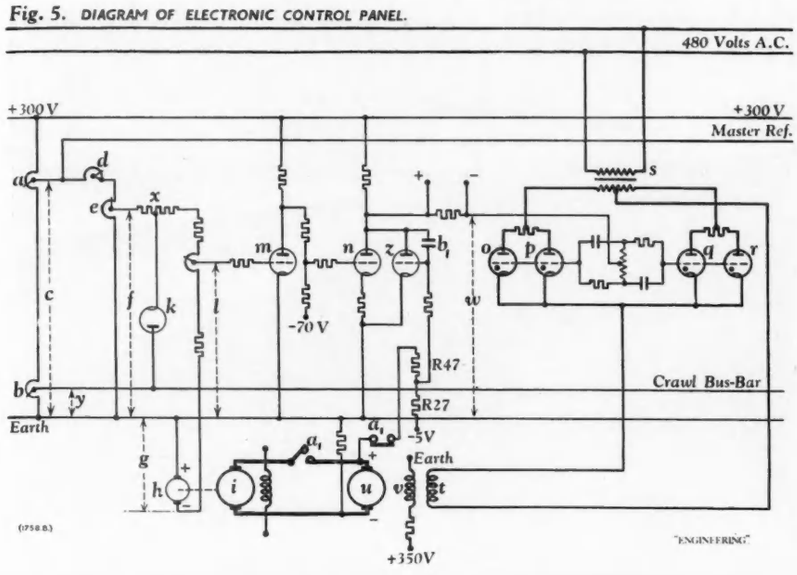
A group of section-control stations is shown in Fig. 4 and, as will be seen, consists of water-tight boxes which are placed in suitable positions at the front or the back of the machine. The controls consist of an "inch" push-button, a "crawl-off run" switch and a draw-control hand-wheel and scale. There is also an ammeter for indicating the load on the section motor. When the "inch" button is depressed the section motor is caused to run at a slow pre-set speed and continues to do so as long as the button is held in. When the control switch is set to "crawl" the section runs at the same slow speed, until the switch is returned to the "off" position. When the control switch is set to "run," the section is accelerated uniformly until it reaches the paper-making speed, which has been determined by the master speed and section draw controls. Turning the control switch to "off" causes the section to come to rest. The speed of the section concerned is adjusted by a wheel which is visible on the right of the control stations in Fig. 4, while the operation of the draw-control switch causes a gradual change in the speed of the section concerned and simultaneously of all the following sections.

A diagram of the electronic control system is given in Fig. 5, opposite, in which the master speed control rheostat is shown at *a*. This rheostat is motor operated and push-button controlled from a master control pedestal. An illustration of this pedestal, which is placed at a point from which the entire front of the machine is visible, is given in Fig. 7, opposite. The rheostat *a* is connected in series with the "crawl speed" setting rheostat *b* across the regulated 300-volt direct-current supply. The master reference voltage *c* is applied to the voltage reference circuit of each speed regulator, which comprises a "draw-adjusting" rheostat *d* and a section starting rheostat *e*. The latter is also motor operated and its slider is normally either in the lower position, when the section is at rest or running at crawl speed, or in the upper position, when the section is running at paper-making speed. The voltage, *f*, which is the reference voltage of the section and can be varied with respect to *c* by the rheostat *d*, is compared with the output voltage of the tachometer generator *h*, which is coupled to the section motor *i*. A voltage *l* is applied to the grid-cathode circuit of valve *m* and changes in response to variations in either voltages *f* or *g*. Valves *m* and *n* with their associated components constitute a two-stage direct-current amplifier, which controls a phase-shift network in the grid circuits of thyratrons *o*, *p*, *q* and *r*. These four thyratrons, in conjunction with the rectifier transformer *s*, provide the excitation for field *t* of the generator *u*. A negative bias field *v*, which is supplied from the exciter limits the current range of *t*, which is required to effect a 100 per cent. change in the armature voltage of the generator. The magnitude and polarity of the voltage *w* determines the voltage applied by the thyratron rectifier to the generator field.

As regards the operation of this speed-regulating circuit, if the load on a section is reduced, the speed of its motor *i* and the voltage *g* will tend to increase. As a result the grid voltage of valve *m* will become more negative and its anode current will decrease. On the other hand, the grid voltage of the valve *n* will become less negative and its anode voltage will increase. The resulting fall in anode voltage will then produce a decrease in the voltage *w* and thus a reduction in the generator field current and of the voltage applied to the section motor.

ELECTRONICALLY-CONTROLLED PAPER-MAKING MACHINE.

Fig. 5. DIAGRAM OF ELECTRONIC CONTROL PANEL.



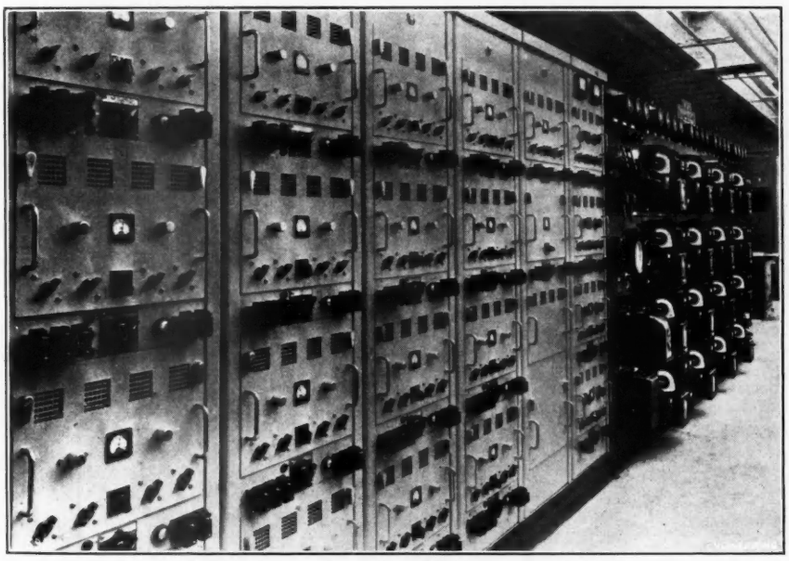


FIG. 6. ELECTRONIC AND CONTACTOR CONTROL GEAR.

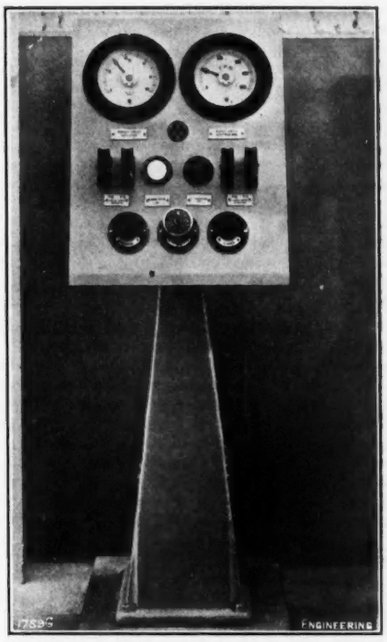


FIG. 7. MASTER CONTROL PEDESTAL.

The actual rise in speed which takes place is extremely small. In fact, in the Guard Bridge installation, a 0·03 per cent. change in speed alters the generated voltage of about 60 volts by an amount which is slightly more than the total resistance drop in the armature circuit with full-load current. Thus, the change in speed, which would result from a 100 per cent. change in load, is less than 0·03 per cent. In practice, changes in load are much less than this and speed variations are mainly caused by alterations in the resistance of the components in the speed-measuring circuit and in the tachometer-generator voltage. These variations have been reduced to a minimum by careful design, so that the greatest possible variation in speed from all causes is less than 0·1 per cent.

As regards operation, when the section motor is stationary the slider of the starting rheostat e is in its lower position and the voltage f is zero. To operate at "crawl" speed the anode of the valve k is connected to the slider of the "crawl speed" rheostat b, while its cathode is connected to the centre of the resistor x. When the voltage f is greater than the voltage y, the valve k is non-conducting, but when it becomes less than y its anode becomes positive to the cathode and current flows. The voltage drop across the valve, however, is small, with the result that the centre tap of the resistor x is held at substantially the same voltage as the slider b. The voltage y is therefore the reference voltage with which the voltage f is compared when either the section control switch is moved to "crawl" or the "inch" push button is pressed.

With this type of drive no starting resistances are necessary in the armature circuit. It is essential, however, to ensure that the generator voltage is very low before closing the armature contactor a_1 in Fig. 5. The coil of a voltage relay, which is not shown in this diagram, is therefore connected across this contactor and prevents it closing unless this requirement has been fulfilled. The valve z, in Fig. 5, enables the generator voltage to be regulated to a low value when the contactor a_1 is opened. This is done by connecting the positive terminal of the generator to the grid of valve z and comparing its voltage with a five-volt reference source. In this way valve z is used to control the rectifier, which supplies the field t of the generator. When the contactor a_1 is closed the generator armature is disconnected from the grid circuit of valve z, which moves negatively at a rate determined by the condenser b_1. The voltage w therefore rises until the speed reaches its "crawl" value when once again the speed regulator takes over control and raises the speed to the operating value, while the valve z remains non-conducting until the next starting operation.

All the electronic control equipment just described is housed in sheet-steel cubicles, as shown in Fig. 6. The speed and voltage regulators are carried on easily-removable sliding trays. Plugs and sockets are provided for connecting the trays and cubicle wiring. Spare trays for both the speed and voltage regulators are also accommodated in the cubicles. These are kept energised to maintain the valve cathodes at working temperature, so that in case of failure a rapid replacement can be made. The contactor gear, which can be seen to the right of the electronic equipment in Fig. 6, consists only of a line contactor, line isolator, and field switch inching and protective relays.

A different system of speed control from that just described is employed on the centre driven reel, which forms the final section of the machine. This is due to the fact that as the reel builds up in diameter its speed must be progressively reduced and the torque exerted by the motor must rise in proportion to the diameter in order to maintain a constant tension in the paper. These requirements are most readily met by using a direct-current shunt motor the required speed control being obtained by adjusting the field, while the armature voltage is varied in proportion to the paper speed and the armature current is kept constant to maintain constant tension. The reel motor armature is supplied through a six-phase half-wave rectifier and the shunt field through a single-phase full wave or bi-phase rectifier. The armature voltage is regulated by comparing the master-speed reference voltage in a two-stage electronic amplifier, and the shunt field current is controlled by the difference between a voltage proportional to the armature current and a stabilised reference voltage. The reel motors are operated from control stations at which "start" and "stop" push buttons are provided. The only other controls are two rheostat knobs, one of which is used to set the tension to be maintained in the sheet and the other to regulate the speed of the reel manually when matching the peripheral speed of an empty reel to that of a full one.

BLITHFIELD RESERVOIR.

BLITHFIELD Reservoir, opened by Her Majesty Queen Elizabeth the Queen Mother on October 27, has been completed for the South Staffordshire Waterworks Company in this their centenary year. The reservoir, as seen from the top of the principal embankment, is shown in Fig. 1, herewith. The South Staffordshire Waterworks Act was passed in 1853, authorising the company to supply water to nearly a quarter of a million persons, in an area of about 75 square miles, mainly in the industrial district of South Staffordshire, though the northern portion was agricultural. The major part of the area had, at the time, no public water supply, and, particularly in the southern or industrial section, many people depended on wells of doubtful quality, or even on canals or mine-drainage water.

A start was made during the 1850's by constructing two small impounding reservoirs at Lichfield, which was then in the northern part of the company's area of supply, and a pumping station, trunk mains, and auxiliary works were provided for distributing the water. A few years later, the company constructed a further small impounding reservoir a short distance north of Lichfield. These three reservoirs were, for many years, the only impounding reservoirs the company possessed. Development was continuous, however, and for a considerable period the increasing demand for water was met by pumping stations drawing on the underground supplies from the water-bearing sandstones in the Trias formation.

At the older pumping stations, wells, varying from 8 ft. to 16 ft. diameter, and from 72 ft. to 196 ft. deep, were sunk. These were followed, in the more recent installations, by boreholes varying from 48-in. diameter at the top to 18 in. at the base, and from 233 ft. to 1,058 ft. deep. At the present time, the company have 36 pumping stations in use within and adjacent to the statutory area of supply. Of these pumping stations, 22 are engaged in primary pumping for the abstraction of underground water; the remainder are re-pumping stations, which are necessary because of the undulating nature of the supply area, which varies in elevation from 140 ft. to 932 ft. above sea level.

As a result of the developments which have taken place since the passing of the 1853 Act of Parliament, the company's statutory area of supply now covers 467 square miles, extending into the counties of Staffordshire, Worcestershire, Warwickshire and Derbyshire, and the estimated population supplied with water is about 975,000. The mains in use, which are up to 36 in. in diameter, total 1,887 miles, and the average daily consumption of water in the area is 36·618 million gallons.

Some years prior to the 1939-45 war, it had become apparent that the underground water resources in the company's area were approaching full development, and that additional sources would have to be sought. In 1939, an Act of Parliament was obtained, giving authority to impound the River Blithe, which flows through the area to join the River Trent. Auxiliary works, including the diversion of roads, the construction of a pumping station and water purification works, extensions to two existing service reservoirs, and the laying of a new trunk main, were also authorised by the 1939 Act. Owing to the war, it was not until 1947 that it was possible to commence work. The River Blithe scheme has been carried out under the direction of the South Staffordshire Waterworks Company's engineer, Mr. R. A. Robertson, B.Sc., M.I.C.E. The consulting engineers were G. H. Hill and Sons, 51, Mosley Street, Manchester, 2, whose senior partner, Mr. H. Prescott Hill, M.I.C.E., was primarily responsible for the design and execution of the reservoir. The resident engineer on the site was the late Mr. A. R. C. Ball, B.Sc., M.I.C.E., and the principal contractors were John Mowlem and Company, Limited, London, S.W.1.

RESERVOIR SITE.

The site chosen for the reservoir is an agricultural area near Rugeley, Staffordshire, where the River Blithe passes through a wide, flat valley, the floor of which is of alluvial sand and gravel, heavily charged with ground water, and varying from 15 ft. to 25 ft. in thickness. As may be seen from the accompanying map, Fig. 2, an embankment has been built across this valley a short distance below the point at which a small tributary, the Tad brook, joined the river. The resulting reservoir is 790 acres in extent at top-water level, which is 312·5 ft. above mean sea level, and the capacity is 4,000 million gallons. The catchment area covers 27,000 acres, and extends northwards from the reservoir for a distance of 17½ miles, varying in width from 1½ to 3½ miles. The elevation of the catchment area is from 312·5 ft. to 915 ft. above mean sea level. It lies principally on the Keuper marls, with a small part on the coal measures at the northern end. For about 12 miles upstream of the reservoir, the catchment area is almost entirely agricultural, but the northern part has a considerable population, and is still developing. To reduce pollution of the river, an agreement was entered into with the Corporation of Stoke-on-Trent and the Rural District Councils of Stone and Cheadle, in whose areas the development is taking place, for the diversion of sewage from the Blithe valley into another river, the Tean. This agreement was embodied in the 1939 Act of Parliament. In order to exercise additional control over possible sources of pollution, the company purchased a total of 2,350 acres of land at the reservoir site, 1,100 acres of which are devoted to farming. The long-term annual rainfall over the catchment area is estimated to be 31·3 in., and the available yield is assessed at 16 million gallons per day, of which quantity 5 million gallons must be discharged to the River Blithe below the reservoir, as compensation water.

BLITHFIELD RESERVOIR.

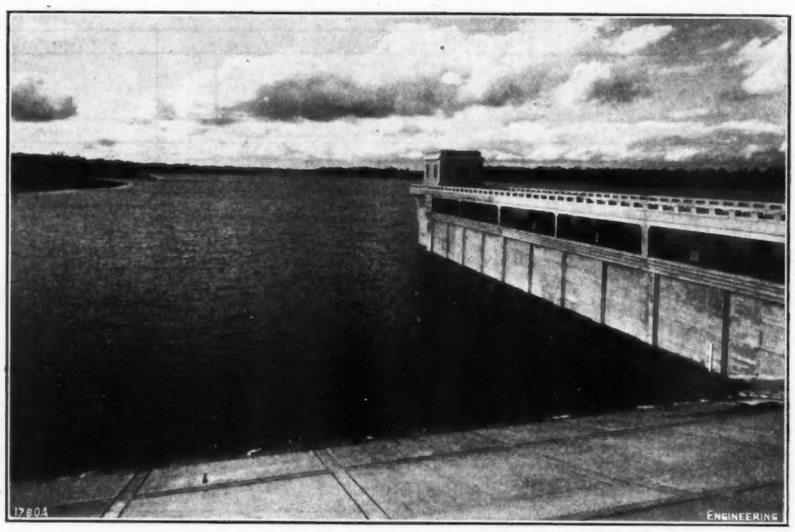
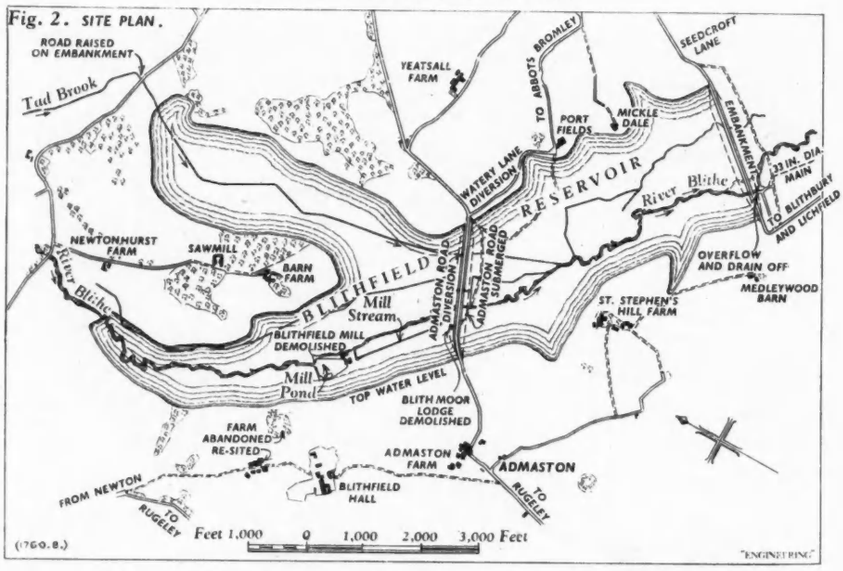


FIG. 1. RESERVOIR AND VALVE HOUSE.



THE EMBANKMENT.

The essential feature of the Blithfield Reservoir is an embankment some 2,810 ft. long, straight across the valley. The view looking along the top of the embankment, with the valve house and overflow works in the mid-distance, is shown in Fig. 3, on Plate XXXIII. The embankment is 305 ft. wide at the bottom (at the maximum section), and 14 ft. 6 in. wide at the top. The height, at the maximum section, is 52 ft. 6 in. A typical cross-section of the embankment is reproduced in Fig. 7, opposite. To prevent the passage of water under this embankment, it was necessary to sink a cut-off trench, 3,250 ft. long, along the centre-line. The trench was excavated through the alluvial deposits into the underlying marl, and filled with mass concrete to ground level. The upper section of the trench was 10 ft. in width, reducing to 6 ft. on entering the marl. A suitable foundation of compact marl was reached at depths varying

BLITHFIELD RESERVOIR, ABBOTS BROMLEY, STAFFORDSHIRE.

(*For Description, see Page* 598.)

FIG. 3. TOP OF EMBANKMENT.

FIG. 4. OVERFLOW CHANNEL AND STILLING POOL.

FIG. 5. CHANNEL AND POOL, SHOWING SCOUR PIPES.

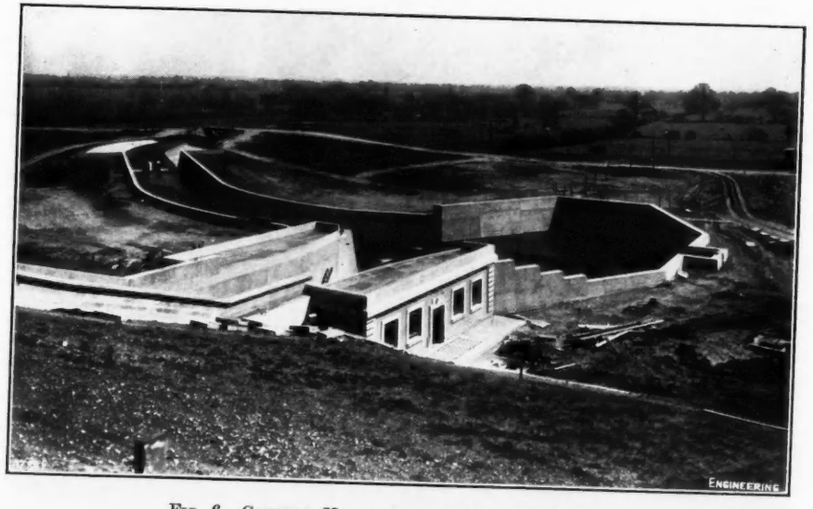
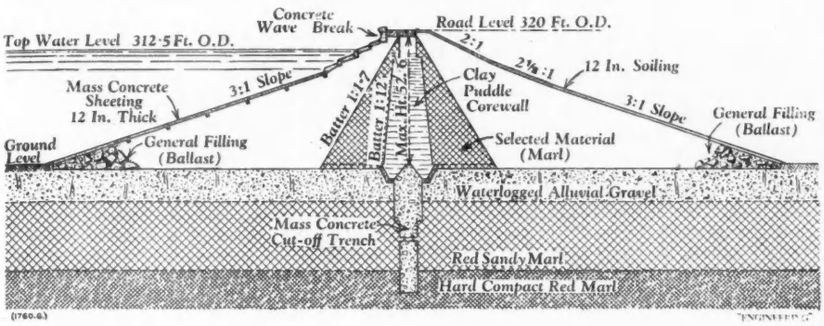


FIG. 6. CONTROL HOUSE, POOL AND RIVER CHANNEL.

(*To face page* 598.)

BLITHFIELD RESERVOIR.

Fig. 7. TYPICAL SECTION OF EMBANKMENT. (NOT TO SCALE).



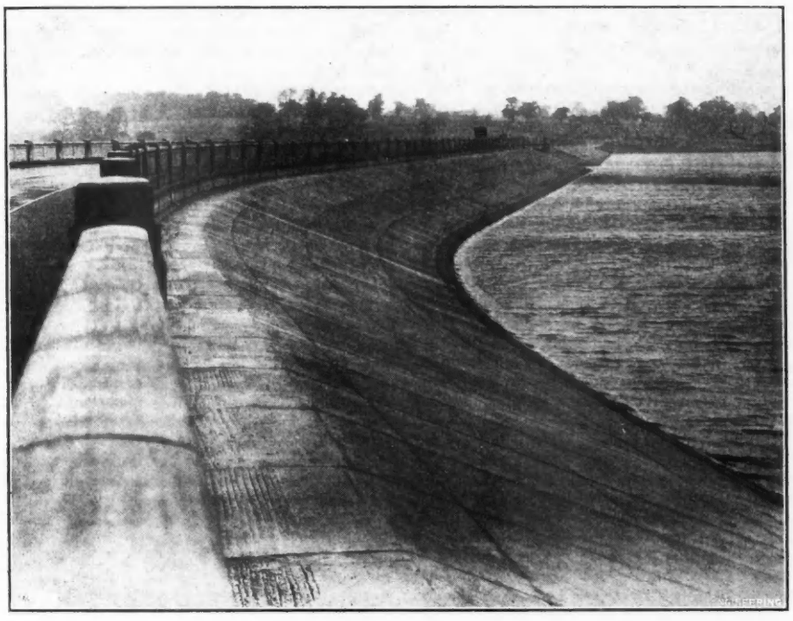


FIG. 8. EMBANKMENT FOR ROAD DIVERSION.

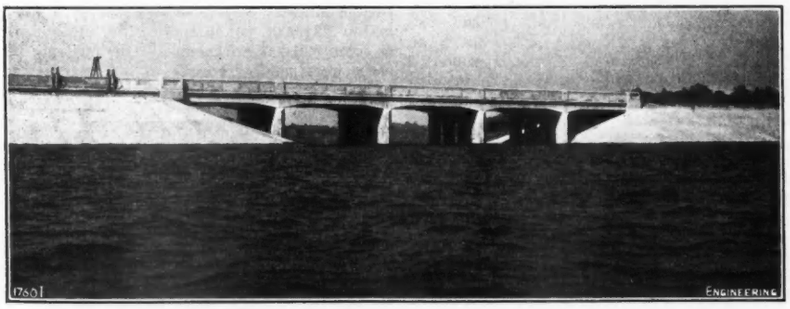


FIG. 9. BRIDGE CARRYING ROAD DIVERSION.

between 46 ft. and 108 ft. below the surface of the ground; the average depth was approximately 80 ft. The cut-off, which contains 63,000 cub. yds. of concrete, terminated at ground level in a specially-designed profile to ensure a watertight joint with the puddled-clay corewall, which extended above it to form a watertight barrier along the centre of the embankment.

The maximum width of the puddled-clay corewall at ground level was 16 ft., tapering to a width of 9 ft. at 18 in. below top water level. Above this point the corewall had a uniform width of 6 ft. to its termination about 5 ft. above top-water level. The marl excavated from the cut-off trench was used in the construction of the embankment, being placed next to the puddled-clay corewall. The outer slopes of the embankment, flanking the marl, are of sand and gravel. The 3 : 1 upstream, or water, face of the embankment is dressed with concrete formed in panels, each about 14 ft. square and 12 in. thick, cast *in situ* and covering 35,100 sq. yds. in all. The joints between the panels are filled with fine gravel to permit easy drainage. In the upper part of the protective sheeting there is a series of steps, which terminates in a mass-concrete coving and a concrete coping, the whole being designed as a wave-break. On the down-stream side the slopes of the embankment vary between 3 : 1 at the base and 2 : 1 at the top, with an intermediate slope of 2½ : 1. This face of the embankment has been covered with soil to a depth of 12 in., and grass seeded. The total amount of material in the embankment is 546,000 cub. yds.

VALVE SHAFT AND OVERFLOW WORKS.

The valve shaft, the overflow or spillway, and the discharge tunnel were designed as a single stuctural unit, and in this respect are probably unique. They can be seen in Fig. 3, Plate XXXIII. The structure is of reinforced concrete, and is situated near the south-western end of the embankment. The discharge tunnel is of horseshoe section with a maximum width of about 14 ft., and contains two 33-in. diameter mains, so arranged that either can deal with water for supply, for compensation, or for scour purposes. Two draw-off pipes are laid at the bottom of the valve shaft, with a third draw-off pipe, 21 ft. below top water level, connected to them. The tunnel leads to a control house which contains the control valves for regulating the amount of water discharged to the tail-bay for scour and compensation purposes, as well as the control and self-closing valves on the supply mains. A 33-in. diameter trunk main leads to the pumping station and purification works at Seedy Mill, about five miles away, which have been constructed to deal with the water from the reservoir.

The overflow works consist of a reinforced-concrete U-shaped channel, 20 ft. in width, which passes through the embankment above the discharge tunnel. Upstream of the embankment, the overflow channel extends into the reservoir to end at the valve house, the tops of the channel side-walls being horizontal to form the overflow sills, as shown in Fig. 1. Each sill is approximately 140 ft. long and 35 ft. 6 in. above the channel invert. On the down-stream side, the overflow channel, after passing over the roof of the control house, discharges into a large stilling pool, from which there is a water-course, 30 ft. wide, with mass-concrete sides and invert, to return the water to the River Blithe. These works are shown in Figs. 4, 5 and 6, on Plate XXXIII. A standing-wave flume, to measure both compensation water and flood water, is built into the water-course.

ROAD DIVERSIONS.

As indicated in Fig. 2, two road diversions were necessary as a result of the construction of the reservoir, and a short section of public highway at the north end had to be raised by a maximum of 4 ft. An accommodation road, Wattery-lane, on the north-east side of the river valley was submerged, and to replace it, 770 yards of new concrete road have been constructed above top-water level. The second road affected was a public highway from Rugeley to Abbots Bromley, which crossed the river valley at approximately the middle of the site, and an earth embankment has been constructed to carry this road over the reservoir. Fig. 8, herewith, shows the embankment as it is seen from the west bank of the reservoir. The embankment has a maximum height of 35 ft., and contains 328,000 cub. yd. of sand and gravel excavated from the reservoir basin. It is 2,760 ft. long, and has a width of 53 ft. 6 in. at the top, where it carries a roadway 24 ft. wide. The bottom width of the roadway embankment at the maximum section is 215 ft. Both faces are protected by mass-concrete sheeting, cast *in situ*.

At the centre of the embankment there is a communicating channel between the two parts of the reservoir, over which the roadway is carried on a reinforced-concrete bridge, shown in Fig. 9. The bridge has five spans, three of 47 ft. 6 in. and two of 38 ft. 6 in. span. The width between the parapets is 40 ft.

RESERVOIR BASIN.

As the reservoir is sited in an agricultural area, only two small buildings, a lodge and a water mill, were submerged. A farm on the west side has been abandoned and re-sited owing to its close proximity to top-water level. The basin was cleared, as far as practicable, of all hedges and undergrowth, which were grubbed-up and burnt on the site. Marsh land was drained, and all trees were felled and removed, the stumps of trees not exceeding 20 ft. below top-water level being treated with sodium chlorate to prevent re-growth. An

area of approximately 55 acres of woodland and scrub, containing about 11,000 trees of varying sizes, was dealt with, and seven miles of hedges were removed. A considerable acreage of pasture land was ploughed up, and crops of mixed corn were taken immediately before impounding commenced, in order to reduce the amount of organic matter remaining.

CONSTRUCTION.

A total of 495 men were employed on the construction of the reservoir. A camp capable of housing 130 men was constructed on the site, and a somewhat larger number was housed at another camp a few miles away. The remainder of the labour force was transported daily, in motor coaches, from neighbouring areas.

The cut-off trench was excavated in sections enclosed by interlocking steel-sheet piling to exclude some of the ground water, the piling being driven, in advance of the excavations, into the underlying marl. A considerable amount of ground water had to be dealt with, a maximum quantity of two million gallons being pumped in one day from the various sections of the trench where work was in progress. The trench was filled with mass concrete in lifts of 4 ft. 6 in., the ground water being temporarily diverted during placing—an operation which called for considerable skill and ingenuity. Locomotive cranes running on rail tracks alongside the trench were used for excavating and filling. A section of the trench in the vicinity of the river was left unopened until the river could be diverted over a completed portion of the concrete filling. This was done about 100 yards to the north-east of the original course of the river. Finally, the river was diverted through the discharge tunnel while the embankment was completed across the valley.

The filling for the outer slopes of the embankment consisted of alluvial gravel dredged from lagoons in the floor of the valley within the reservoir area. Dragline excavators were used for dredging the material, which was then transported in tipping lorries of from 5 to 15 tons capacity. Good compaction of the material was obtained by the use of this method of transport, supplemented by bull-dozers and vibratory rollers. Clay for the corewall was obtained from a deposit about 1½ miles up the valley, and the clay was treated at the site in pug mills. Puddled clay from the pug mills was placed in layers 4 in. thick over the area of the corewall, and "heeled" into a compact watertight mass. Marl excavated from the cut-off trench and elsewhere in the reservoir basin was used to support the sides of the corewall.

Washing, crushing and screening equipment was erected at the site, and the bulk of the sand and gravel used in concreting was prepared there from materials excavated from the reservoir below the top-water level. Temporary roads were made by tipping and consolidating the natural gravel, to give access to the embankment, the clay pit, sand and gravel plant, as well as the gravel lagoons.

The work of construction of the embankment was started in the autumn of 1947. Work on the diversion of the Rugeley-Abbots Bromley road commenced in June, 1950, and was substantially complete by June, 1952, except for the construction of the parapet walls, which were left until 1953 to allow consolidation of the embankment to take place first.

"MECHANISED WELDING NEWS."—Fusarc Ltd., Gateshead-on-Tyne, have published the first number of a bulletin entitled *Mechanised Welding News*. This will replace the production news sheets hitherto published by the firm and will enable more space to be given to "case histories" of actual welding problems. Technical descriptions of equipment and other items of interest to those concerned with automatic welding will be included.

NEW EXPLOSIVES DEPOT.—A plot of land at Fisherwick, near Lichfield, Staffordshire, has been taken over by Imperial Chemical Industries, Ltd., for the erection of an explosives store. A licence has been obtained for the storage of explosives, and planning consent has been given. No manufacturing will be carried out at the new depot, which is intended as a store from which the mining industry and factories north of Birmingham can be supplied.

LABOUR NOTES.

ADDITIONAL arguments in favour of the engineering employees' wage claim were placed before representatives of the Engineering and Allied Employers' National Federation at a joint meeting with officials of the Confederation of Shipbuilding and Engineering Unions in London on October 29. Mr. Jack Tanner, who is this year President of the Trades Union Congress as well as of the Amalgamated Engineering Union, contended, on behalf of the Confederation, that it was wage rates and not total earnings, including remuneration for overtime, which should be offset against the current cost of living. He is believed to have referred, in further support of the Confederation's case, to various particulars relating to wage rates, earnings, and living costs, contained in recently-issued Government publications, and to have sought to show that the hourly earnings of engineering employees have not kept in step with the rising cost of living. Some of the statistics quoted are understood to have been based on the Treasury's *Bulletin for Industry*.

On behalf of the Engineering Employers' Federation, Sir Percy Mills, Bt., the President, asked for time to examine in detail the further particulars submitted on behalf of the Confederation, and promised that they should be carefully taken into account. He warned the trade-union leaders, however, that he would only be deluding them if he did not make it clear to them that the employers' representatives had seen nothing in the new statement up till then to justify any increase in wages beyond that conceded in November, 1952. The case for the Federation, it may be recalled, was presented at a joint meeting of the two sides on October 7. In this, as briefly reported on page 504, *ante*, Mr. B. Macarty, the director of the Federation, affirmed that earnings in the engineering industry had risen more rapidly than the level of the interim index of retail prices.

It was arranged that a further meeting of representatives of the two sides should be held in London yesterday afternoon, at which the Engineering Employers' Federation would make known their final decision. This reply will be considered at a meeting of the executive council of the Confederation in York next Thursday. The next quarterly meeting of delegates from the 38 unions affiliated to the Confederation is due to take place at York during the following week, and it is likely that any additional steps, which may require to be taken in connection with the wage claim, will be decided upon then. The claim was formally presented to the employers on July 21 and seeks to obtain an additional 3*s.* in the pound on the consolidated rates of all adult male operatives in the engineering and associated industries, including both time and piecework employees.

A corresponding wage claim asking for an increase of 15 per cent. in the wages of adult male employees in the shipbuilding and ship-repairing industries was rejected outright by the Shipbuilding Employers' Federation on October 14. In this connection, it was announced recently that leaders of the Confederation would meet representatives of the employers' Federation yesterday morning in order to present additional statistics and arguments.

Increases in wages, amounting to 4*s.* a week for men and 3*s.* a week for women, have been granted to labourers in the employ of local authorities in England and Wales. These workpeople, whose wages are determined by the National Joint Council for Local Authorities' Services (Manual Workers), recently had their claim for higher pay submitted to the Industrial Disputes Tribunal. The unions representing them asked for an increase in wages sufficient to offset the depreciation of real wage standards since the operatives' last increase, which became effective in December, 1952.

The award was made subject to the proviso that, in cases where the existing wage rates are in excess of those prescribed by the national agreement for these grades, dated April, 1949, and as subsequently amended, the amount by which such wage rates exceed those provided for by the national agreement shall merge in the wage increases conceded by the present award. No objection appears to have been made by the men's unions to the inclusion of this proviso in the award of the tribunal.

The executive council of the National Union of Mineworkers met in London on October 29 to consider the circumstances arising from the rejection by the National Coal Board of the union's wage claim on behalf of the lower-paid miners. After a fairly long session, the council decided to ask the Board to review the rejection of the claim, on the ground that some material facts were not taken into account on that occasion. It had been estimated that some 400,000 day-wage miners were involved in the claim and that the cost of meeting it in full would amount to at least fourteen million pounds a year. Sir William Lawther, the President of the union, stated after the meeting that the claim for another 2*s.* 3*d.* a shift for underground miners and of 2*s.* 1*d.* a shift for surface employees had not been refused because it was not justified, but almost entirely because the industry could not afford to meet the claim without increasing the price of coal by about 1*s.* 6*d.* a ton.

Sir William suggested that the cost of the claim could more easily be met if higher prices were charged to industry for special grades of coal, and particularly for the high-grade coking coal used by the iron and steel industry. He referred to the glowing picture which had been presented to those who might wish to invest in that industry and considered that, if iron and steel undertakings could offer such profits, it was not fair that the Board's losses in mining coking coal should be borne by those coalfields which worked at a profit. This meant that there were no reserves left in the mining industry for the payment of wage increases. He said that it was estimated that coal was being sold to some steel and engineering establishments at 20*s.* a ton less than the cost of production. The time had arrived for the removal of Government control on the price of coal. The Board, which had hitherto been compelled to sell at uneconomic rates, should now be permitted to fix its own prices. At the time of going to press it was stated that a further meeting between the two sides was likely to take place shortly.

Changes in the rates of wages, which came into operation in the United Kingdom during September, resulted in an aggregate increase that was estimated by the Ministry of Labour to amount to approximately 221,000*l.* net in the weekly full-time wages of some 926,000 workpeople. On the other hand, there were small decreases in the wages of some 12,000 workpeople owing to the decline of the index-of-retail-prices figure. These decreases amounted, in all, to 300*l.* a week net. The increases principally affected certain classes of domestic employees, agricultural workpeople in Scotland, persons employed in retail food distribution, and those engaged in the manufacture of boots and shoes. During the first nine months of this year, a total of 6,931,000 persons in the United Kingdom have received increases in their full-time weekly wages amounting to 1,875,300*l.* In the corresponding months of 1952, there was a net increase of 3,173,000*l.* in the weekly wages of 8,058,600 persons.

There were 1,217 trade disputes in progress in the United Kingdom during the period from January to September, 1953, inclusive, and some 196,800 workpeople took part in them, at the cost of 838,000 working days. The comparative figures for the corresponding nine months of last year, according to the *Ministry of Labour Gazette* for October, were 1,327 strikes in progress, with 294,400 persons involved in them and 1,440,000 working days lost. During the first nine months of the current year, there were 38 stoppages in the ship-building and ship-repairing industry, and 7,200 operatives took part and lost a total of 63,000 days. Only 30 strikes occurred in the engineering industry, however. In these, 7,700 persons took part.

USES FOR BAILEY BRIDGE EQUIPMENT.

THOMAS STOREY (ENGINEERS), LIMITED, STOCKPORT.

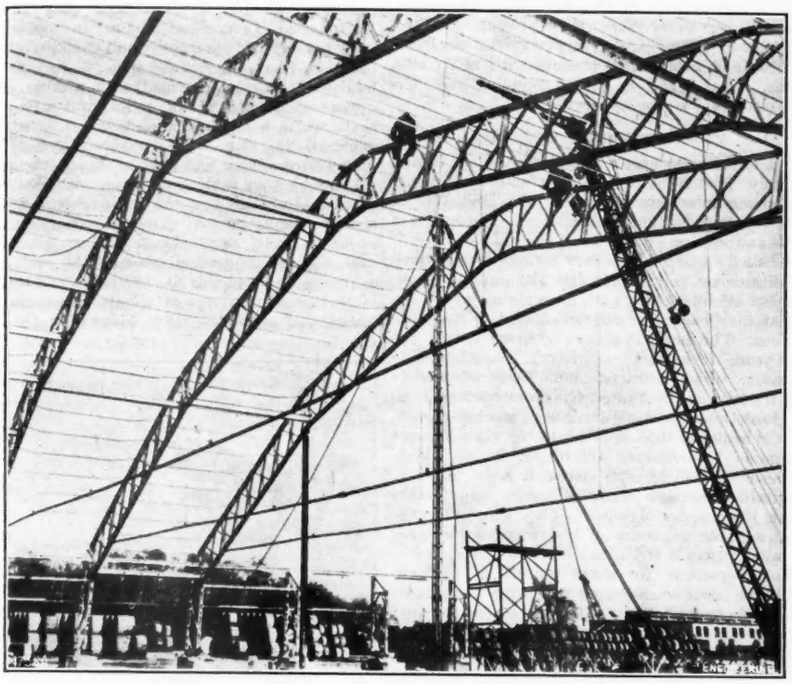


FIG. 1. PORTAL FRAMES FOR A WAREHOUSE BUILDING.

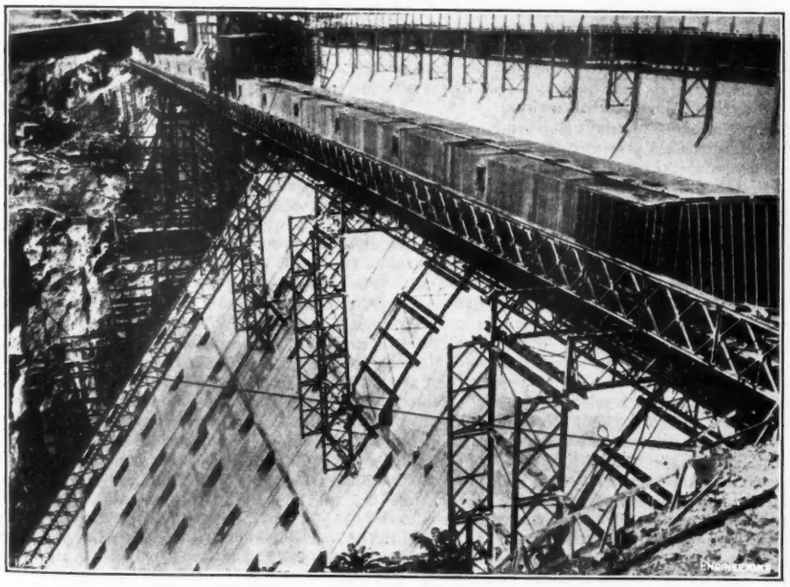


FIG. 2. CONVEYOR BRIDGE USED IN THE CONSTRUCTION OF A LARGE DAM.

USES FOR BAILEY BRIDGE EQUIPMENT.

THE value of the Bailey bridge units for the provision of temporary bridges during the last war is so well recognised as to require no further comment. But the very recognition of their war-time value has tended to associate them with war-time activities alone and to obscure the advantages that they offer as an expedient in civil-engineering work in peace time. Since the war, however, Bailey bridge units have been employed widely throughout the world on a variety of work, two examples of which are illustrated in the accompanying Figs. 1 and 2. Fig. 1 shows the panels used as single units for constructing rigid portal frames of 153-ft. span for a warehouse-type building; Fig. 2 illustrates an alternative use, in which the units have been employed to build a conveyor bridge supported on bents during the construction of a large dam for the Hydro-electric Power Commission of Ontario. The units also make excellent supports for falsework for exceptionally heavy reinforced-concrete work, such as dams, sea walls or long-span bridges. For the construction of dykes in flooded areas, the units are readily assembled as frameworks which are then used to ensure that the filling is not washed away.

The features of the equipment are its lightness, simplicity, high quality and accuracy, which allows a full interchangeability of parts. No special site plant or mechanical aids are required during erection, nearly all normal constructions being within the scope of man-power aided only by a light block and tackle. The heaviest component made is a panel, 10 ft. by 5 ft., which weighs about 600 lb. All the components can be loaded into standard 3-ton lorries for transport to site. To satisfy any particular load and span requirements, the units possess a wide adaptability which permits them to be used either singly or in multiple combinations. The limit of fixed-span bridges is about 200 ft., but the introduction of intermediate piers or cribs (built of the same units) or the use of the equipment to build only the road deck slung below cables, as for a suspension bridge, allows much greater spans to be covered.

The production of the war-time equipment was originally controlled by the United Kingdom Ministry of Supply, but since 1950 the world licence for making and for the sale of the components has been held by Thomas Storey (Engineers), Limited, Stockport, Cheshire. At a recent Press conference, Mr. Thomas Storey, managing director of the company, detailed the variety of purposes to which the equipment has been put in recent years. Particularly did he emphasise the value of the equipment in time of emergency: because of the high speed of erection it is possible to bring diversionary roads into operation within a few hours, so enabling vital traffic to be kept on the move. For the United Kingdom, Bailey bridge equipment is available for hire to contractors who do not wish to carry large stocks themselves. Apart from the equipment used in this country, a very large percentage of the total output is sent overseas and delivery has already been taken in Belgium, India, Australia (for, amongst other projects, the Snowy Mountains Hydro-electric scheme), Canada, and the United States.

LAUNCHES AND TRIAL TRIPS.

M.S. "ST. JOHN."—Single-screw cargo vessel, built by Joseph L. Thompson and Sons, Ltd., Sunderland, for the South American Saint Line, Ltd., Cardiff. Main dimensions: 440 ft. between perpendiculars by 59 ft. 4 in. by 39 ft. 8 in.; deadweight capacity, about 9,600 tons on a draught of 26 ft. 9 in. Five-cylinder opposed-piston oil engine, developing 5,300 b.h.p. at 114 r.p.m., constructed by William Doxford and Sons, Ltd., Sunderland. Service speed, 14 knots. Launch, September 22.

M.S. "NEPTUNE."—Single-screw cargo vessel, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Compañia Naviera Hesperia S.A., Panama City, Panama. Main dimensions: 435 ft. between perpendiculars by 60 ft. by 39 ft. to shelter deck; gross tonnage, 5,750. Swan Hunter-Doxford four-cylinder opposed-piston combined-stroke oil engine, developing 4,400 b.h.p. at 115 r.p.m. in service. Launch, September 23.

M.S. "AMBERLEY."—Single-screw cargo vessel, built by the Grangemouth Dockyard Co., Ltd., Grangemouth, for Stephenson Clarke, Ltd., London, E.C.3. Main dimensions: 249 ft. by 38 ft. 6 in. by 18 ft. 6 in.; deadweight capacity, about 2,400 tons on a draught of 17 ft. Eight-cylinder Diesel engine, developing 1,380 b.h.p. at 275 r.p.m., constructed by British Polar Engines, Ltd., Glasgow, and installed by the shipbuilders. Trial trip, September 23.

M.S. "ALVA CAPE."—Single-screw oil tanker, built by the Greenock Dockyard Co., Ltd., Greenock, for the Alva Steamship Co., Ltd. (Managers: Navigation and Coal Trade Co., Ltd.), London, E.C.3. Main dimensions: 545 ft. 3 in. overall by 69 ft. by 38 ft. 6 in. to upper deck; deadweight capacity, 16,590 tons on a mean draught of 29 ft. 10½ in.; oil-carrying capacity, 786,650 cub. ft.; gross tonnage, 11,160. Scott-Doxford six-cylinder opposed-piston oil engine, developing 6,600 b.h.p. at 114 r.p.m. in service, constructed by Scotts' Shipbuilding and Engineering Co., Ltd., Greenock. Machinery installed by John G. Kincaid & Co., Ltd., Greenock. Service speed, 15 knots. Trial trip, September 25.

M.S. "ROYALGATE."—Single-screw cargo vessel, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for the Hullgates Shipping Co., Ltd., Hull. Main dimensions: 175 ft. by 27 ft. 6 in. by 11 ft. 6 in.; deadweight capacity, 700 tons. Seven-cylinder Diesel engine, developing 545 b.h.p. at 300 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Trial trip, October 1.

COMMONWEALTH TELECOMMUNICATIONS.*

By J. A. Smale, C.B.E.

During the last three years the centenary of submarine cable telegraphy and the fiftieth anniversary of wireless telegraphy have been celebrated. It is interesting to reflect upon the process by which co-ordination of these two methods of long distance communication in the Commonwealth has emerged from competition through collaboration and has produced the largest and most comprehensive system of telegraphic communications in the world the strength of which depends on the complementary use of cable and wireless routes. A co-ordinated system of cable and wireless stations came into being in 1929 when Parliament entrusted the telegraphic communications of the Empire to a single operating company, and an Imperial Communications Advisory Committee was set up charged with responsibilities in regard to the institution of new services, the discontinuance of existing services, alterations in rates, the distribution of traffic between alternative routes and the safeguarding of strategical requirements. During the ten years preceding the Second World War great strides were made in the integration of the cable and wireless routes, the use of common telegraph apparatus and signalling systems and the dual training of engineering staff. The problem of creating and preserving a co-ordinated, efficient and economic system was, however, not merely one of internal organisation. The telegraph service was still competitive with both foreign cable systems and foreign wireless organisations and preference for cable or wireless routing in the Empire system itself was biased by the possible earnings of some associated organisations in the different States of the Commonwealth.

At the outbreak of the Second World War there was an enormous increase both in Government and Press telecommunication traffic. In fact, the system was the major instrument through which news and ideas were carried to scattered nations and communities of the Commonwealth; and this news-carrying function is still of undiminished importance. The most prominent place in Commonwealth telecommunication affairs has for many years been occupied by the Australian service, since it has to face the most severe technical difficulties and the direct wireless route suffers from natural handicaps which are beyond direct solution. This prominence was perhaps a major factor in the next change in structure, which was the taking of the industry into national ownership and control both in this country and in the other nations of the Commonwealth. To many experts there seemed no technical reasons for this change. In the United Kingdom, however, it had the outstanding advantages of making Government research and development in both the radio and cable fields more directly available and of establishing a policy of cable renewals which would restore the networks to the highest possible state of efficiency and ensure completely complementary services by both systems. Other advantages, which lie more in the future, are the use of common radio plant for both telegraphy and telephony, the operation of subscriber-to-subscriber telegraphy; and the employment of telephone circuits combined with telegraphy over long submarine cables.

Technical Policy.

As regards the technical policy the controlling factor has been, and seems likely to continue to be, finance. The reliability of the cable network is of enormous value, but it presents our biggest bill. It comprises 150,000 miles of cables, a great deal of which is reaching the end of its useful life. Eight ships are employed on repairs and smaller renewals, while larger renewals are carried out by the Post Office cable-laying ship Monarch. Polythene-insulated cable is used for renewals, thereby either increasing the speed or reducing the size and cost. The change has, however, presented serious mechanical problems in deep water. The most promising development in deep-sea cables is the application of submerged repeaters. In fact, the coaxial repeatered telephone cable is now firmly established for relatively short routes in modest depths and a multi-channel telephone cable across the Atlantic cannot be far away. Even old telegraph cables can be greatly improved by the use of simple submerged repeaters. The most elegant electromechanical relays are giving way to electronic devices and cable ships abound with radio aids, radar, buoy reflectors, depth-sounding recorders and electronic testing apparatus.

Propagational Difficulties.

While the incidence of cable interruptions is only roughly predictable, the uncertainties of long-distance wireless circuits render the prediction of performance even more problematical. The merger of cable and wireless systems took place at the onset of the 1928-33 sunspot minimum period (during which conditions are persistently difficult) and the beam-wireless circuits had a hard struggle to justify the threat they had so recently presented to the cable system. The next minimum occurred during the war years when traffic was heavy, an unfortunate situation which attracted much criticism, while the transfer of the United Kingdom operations to the Post Office could not have been more ill-chosen, for the winter of 1950-51 heralded the worst sunspot minimum conditions. Interruptions to long-distance radio-telegraph circuits are, in fact, inevitable and their duration varies considerably owing to a number of causes. They occur when the most suitable frequency of the circuit is changing so rapidly that it is impracticable to provide additional frequencies for short periods of working. They also occur when the route is partly in darkness and partly in daylight; and the frequencies required for different parts of the route are so dissimilar that no compromise is possible. Both these interruptions are predictable, but others are due to ionospheric atoms which are particularly devastating on routes which pass near the earth's magnetic poles. The Commonwealth network normally provides alternative cable or wireless routes on all services, and relay stations are situated so that the main route is subdivided into sections on each of which the optimum frequency for the time of day is used; or so that quite different routes are set up to avoid the disturbed regions.

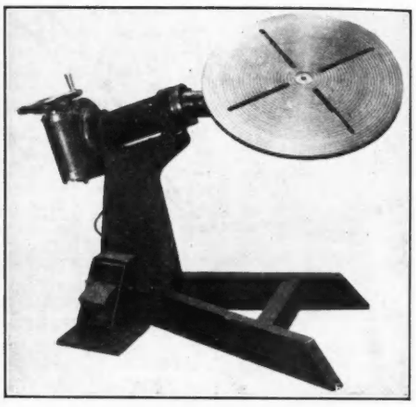
The performance of relays is dependent upon the telegraph distortion present in the received signals. The successful operation of long cable chains is due to the use of regenerators the operation of which is benefited by the employment of a synchronous telegraph system. Electronic regenerators are used in the radio-relay stations on synchronous telegraphy and a mechanical regenerator is employed on Morse relays where the speed is varied with conditions. The general tendency throughout the world is to use the five-unit teleprinter on international circuits. Until 1941 international radio-telegraph circuits with few exceptions used Morse, but after the war, for reasons of more power, the American companies headed a landslide towards the adoption of the five-unit stop-start teleprinter. The Commonwealth system has not yet participated to any great extent in this method of working because the double-current cable code and direct printer had already been widely adopted. A change to a different system of mechanisms was therefore unattractive, especially as the five-unit system had experienced serious difficulties with undetectable errors due to having insufficient redundancy in relation to the signal/noise ratios encountered in practice. The double-current system has considerable error-detecting qualities and the direct printer indicates both unused combinations and unwanted extra spacing. It was adopted as the result of the policy of integrating cable and wireless circuits, as the use of common apparatus simplifies maintenance and training. The seven-unit code, of which there are several forms, has, however, the advantage of permitting a straightforward extension from error detection to automatic error correction.

* Chairman's address, delivered before the Radio Section of the Institution of Electrical Engineers on Wednesday, October 14, 1953. Abridged.

Rapid Loading of Collier.—The collier Captain J. M. Donaldson, owned by the British Electricity Authority, recently loaded 4,300 tons of coal at Blyth, Northumberland, in 11 hours. One hour of this time was used for a meal-break.

POSITIONING APPLIANCE FOR WELDING WORK.

The appliance illustrated below is designed and manufactured by F. Bode and Son, Limited, Burton-road, Leek, Staffordshire, to enable work to be placed in position easily and quickly for downhand welding. As will be seen, it consists of a fabricated pedestal provided with a pillar on the upper end of which is mounted a stout shaft. This shaft, which turns in Timken bearings, is set at an angle of 22½ deg. with the horizontal. Firmly bolted to the inner end of it is an arm the axis of which makes an angle of 22½ deg. with that of the shaft, and on this arm the work table is fitted so that it can be rotated through a complete circle about an axis perpendicular to its plane. By means of hand-operated gearing, the main shaft can be turned and this has the effect of tilting the table through a range of angular positions. For instance, if, with the table horizontal, the shaft



is turned through 90 deg. the table will turn into the vertical position and movement through a further 90 deg. will cause the table to tilt to an angle of 45 deg. facing downwards. A complete revolution of the shaft will, of course, bring the table back again to the horizontal position. At the required angle of tilt the table can be clamped by the pedal seen near the base of the pillar in the illustration, but the table can be turned about its axis by the operator using one hand while his other holds the electrode.

The work plate is 3 ft. in diameter and work-pieces weighing up to 10 cwt. can be clamped to it and turned into any position for downhand welding without any particular attention to balance, provided the eccentricity of the work does not exceed 6 in. and the centre of gravity is not more than 6 in. from the face of the work plate. This is due to the fact that the shaft axis and the axis of rotation of the work plate intersect at a point about 6 in. above the surface of the plate and the point of intersection does not move as the table is tilted. The floor space occupied by the pedestal is 2 ft. 11 in. by 3 ft. 3¼ in. and the height of the work plate in the horizontal position is 3 ft. 1 in. The particular machine illustrated is known as model 10HH/A.

Socket Welded Pipe Unions.—A range of socket-welded unions for piping, from ⅛ in. up to 2 in. nominal bore, has been introduced recently by Shay Products, Ltd., 17, Little St. Leonards, Mortlake, London, S.W.14. They are made from a similar grade of hot forging as is employed on the company's standard range of screwed unions. The materials from which the socket welded unions are made have the same coefficient of expansion as the associated pipes, so that the two can be readily welded. They can be provided with inserted bronze seats, pressed in and secured by spinning, or the seats may form an integral part of the union. Where any trace of sulphur, sulphuric acid, ammonia, etc., is present in the liquid being conveyed through the piping, all-steel unions are recommended to avoid pitting due to electrolytic action. All-steel unions should also be used on superheated steam pipelines. All unions are Parkerised.

TITANIUM—A METAL OF ENGINEERING IMPORTANCE ?*

By P. L. Teed, A.R.S.M., M.I.M.M., F.R.Ae.S., F.I.M.

Wild prophecy in the technological field is, or should be, an unhonoured pastime. Titanium has, however, been a recent victim of this practice. Writers in the popular Press, whose technical knowledge is not always conspicuous, have, during the last three years, described titanium as "The Wonder Metal," "The Metal of the Future," and in even more fantastic phrases. It is fitting, therefore, that the facts should be put before engineers, who can then decide whether it is, or is likely to be, a metal of engineering significance.

What constitutes such a metal is, however, a question of difficulty, and to this broad question no agreed answer has yet been found. This suggests that the evaluation of the significance of titanium should be considered from a purely practical standpoint.

Table I shows to what extent metals are produced. Further, since they are, in the main, employed for engineering purposes, these figures might be taken as indicative of the relative engineering importance of the metals figuring therein.

Table I.—*Approximate World Production of Certain Metals in* 1951.

Steel ingots and castings	208,000,000 tons
Copper	2,588,000 ,,
Zinc	2,155,000 ,,
Aluminium	1,709,000 ,,
Lead	1,600,000 ,,
Tungsten	212,000 ,,
Magnesium	78,000 ,,
Titanium (sponge)	500 ,,
Platinum	15 ,,

The view just outlined, suggesting that the relative importance of a metal from the engineering aspect can be measured solely in terms of the annual output, however, is not sound. Here the Euclidean and extremely valuable *reductio ad absurdum* can be advantageously applied. On the basis of mere relative tonnages, tungsten would seem to be of minor importance. It is, however, the life's blood of the electric resistance lamp industry and, to keep to anatomical analogy, it gives stamina in several other fields, such as the tool steel one. Similarly, on the basis of the yardstick tentatively advanced, platinum would appear to be of trifling significance, yet in certain engineering applications it is essential. This surely establishes that relative magnitude of annual output does not really provide a suitable measure with which to determine a metal's engineering importance. Similarly, relative cost is equally useless for the aim in view—platinum wire of medium gauge is more than 16,000 times the price of mild steel forgings, yet both are necessary in many industrial applications. It thus appears that the engineering significance of a metal exclusively depends neither on the magnitude of its annual production nor on its price per unit of weight. It is, in fact, the possession of one or more chemical and/or physical qualities, which determines whether or not engineers require the metal.

There are over 70 metallic elements, yet the engineer largely confines himself for his mechanisms and structures to the use of the alloys of only four of them, namely, iron, copper, aluminium and magnesium, and in all his activities, he employs, even in a minor degree, less than half the known metals. This relative exclusiveness raises a question—why has titanium after more than a century and a half of neglect, become the subject of international attention. The answer is clear. To use the modern idiom, it is believed to have something which the other metals have not got. The evaluation of this hitherto elusive property or properties is the purpose of the remainder of this note.

The Properties of Titanium.

For the engineer to determine the utility of any metal, he requires information with regard to its physics, mechanics, chemistry, workability and cost. Table II sets out its salient physical characteristics.

Few engineers attach importance to all the properties shown in Table II. Some are primarily the concern of the physicist. Engineers are, however, interested in mechanical properties not generally of significance to the physicist. The most relevant in relation to titanium are set out in Table III. From this it will be noted that the method of manufacture of titanium has, as is indeed the case with many other metals, a very marked influence on its mechanical properties.

Table II.—*Physical Characteristics of Pure Titanium.*

Atomic number	22
Atomic weight	47·9
Crystalline structure :	
Up to 885 deg. C.	Close-packed hexagonal
Above 885 deg. C.	Body-centred cubic
Atomic spacing :	
Up to 885 deg. C.	a = 2·950 Angstrom units c = 4·683 Angstrom units
Above 885 deg. C.	a = 3·31 Angstrom units c = 3·31 Angstrom units
Coefficient of linear expansion	15 to 730 deg. C., 8·8 to 9·2 × 10^{-6} per deg. C.
Thermal conductivity	0·036 calories per sq. cm. per cm. per sec. per deg. C.
Specific heat	0·13
Electrical resistance, microhm per cm. per sq. cm.	60
Density, gm. per c.c.	4·507
Melting point	1,725 deg. C.
Young's modulus, lb. per sq. in.	15 × 10^6

Table III.—*Mechanical Properties of Commercially Pure Titanium.*

Property.	Method of Production. Van Arkel. (1)	Kroll, with Powder Technique. (2)	Kroll, with Induction Melting. (3)	Kroll, with Metal-Electrode Arc Melting. (4)
0·2 per cent. proof stress (tons per square inch)	6·8	28·6	32·2	28·2
Ultimate stress (tons per square inch)	15·6	35·3	35·8	33·5
Elongation, per cent.	55	25	25	29
Hardness, Brinell	57	185	228	—

Table IV.—*Chemical Composition and Mechanical Properties of Some Titanium Alloys.*

Constituents Other Than Ti.	Condition.	0·2 Per Cent. Proof Stress, Tons Per Sq. In.	Ultimate Stress, Tons Per Sq. In.	Elongation, Per Cent.
0·2 Fe, 0·02 N_2, 0·1 O_2	Annealed sheet, bar and forgings	34	39	23
As above	Half-hard sheet	42	49	12
1·8 Si	Annealed bar	38	48	15
7 Mn	Sheet	52	58	15
2·0 Cr, 2·0 Fe, 0·15 O_2, 0·04 N_2, 0·06 C	Bar and forgings	56	62	14
4 Mn, 4 Al	Annealed bar and forgings	60	65	18
2·0 Fe, 2·0 Cr, 2·0 Mo, 0·2 O_2, 0·1 N_2, 0·05 C	Annealed sheet, bar and forgings	56	63	13
2·7 Cr, 1·3 Fe, 0·25 O_2, 0·02 N_2, 0·05 C	Bar and forgings	58	67*	16*
5·0 Cr, 3 Al, 0·5 C	As above	68	74	10

* Depending on grain size and heat treatment, properties ranging from 90 tons per square inch tensile and 6 per cent. elongation down to 60 tons per square inch tensile and 30 per cent. elongation can be obtained.

Since in the main pure metals have few engineering applications, it is appropriate to consider at this stage the mechanical properties of the titanium alloys. In Table IV, the chemical composition and mechanical characteristics of many of the contemporary alloys are set out. The metal will, however, alloy to some extent, with practically anything, including such gases as hydrogen, nitrogen and oxygen. Further, because of the great research efforts which are being made in different countries to produce better alloys, it is difficult to produce a list which is both accurate and contemporaneous.

Before turning to other properties of titanium and its alloys, something more has to be said with regard to its mechanical ones. There are at least two aspects of interest to the engineer. Knowledge as to both impact values and to resistance to fatigue will be required.

Impact Resistance.—As with alloy steels and some other materials, the room temperature notched-bar impact resistance of the titanium alloys tends to decrease with increase in tenacity. A wrought commercially-pure titanium bar (which is really an alloy of titanium with small amounts of iron, carbon, nitrogen and oxygen) may, at room temperature, have a Charpy notch-bar value largely exceeding 50 ft. lb., while that of many of the stronger alloys may not, under similar conditions, absorb as much as 10 ft. lb.

Fatigue Characteristics.—As regards fatigue, at room temperature and employing standard unnotched rotating-beam or push-pull test pieces, the resistance of titanium and of its alloys is impressively high—there can be little doubt that, percentagewise, on the basis of 10 million stress reversals, this exceeds 50 per cent. of the ultimate static tensile stress of the material. With regard to notched specimens a less happy report has to be made. Much more work has yet to be done. The impression rather than the conviction arising from that which has been done is that the metal and its alloys are very definitely more notch sensitive than alloy steels of the same static strength. Further, there is some evidence to show that as the stress concentration factor is increased, endurance is reduced to a considerably greater extent than would be the case with steels having similar static mechanical properties.

Properties at Elevated Temperatures.—Though, as will have been seen from Table II, titanium has a high melting point (about 200 deg. C. higher than that of pure iron), it and the better-known of its alloys are distinctly temperature conscious. As regards such static properties as yield stress, ultimate tensile stress and elongation, the influence of heat is indicated in Fig. 1, page 604. In Fig. 2,[1]* the variation in specific creep of one of the titanium alloys the suitability of which for axial-compressor blading has been under investigation is contrasted with two possible alternatives. Since this work was carried out, yet another titanium alloy has come into being. This gives promise of better elevated-temperature creep characteristics.

Rubbing Properties.—Prior to leaving the mechanical properties of titanium and its alloys, one troublesome defect has to be mentioned. Both have quite deplorable rubbing properties. The metal is inclined to pick-up not only on itself but also on any other on which it is rubbing. At least for the present, this cold-welding tendency debars the use of the alloy for shafts unless these have a sleeve to provide a rubbing surface in the journals, or ball or roller races are fitted. A titanium internal-combustion engine piston, attractive though it seems from several points of view, is unlikely in the near future to be a practical proposition. It is even doubtful if a titanium-alloy nut can be satisfactorily used in connection with a bolt of similar composition. Experiments are, however, in hand having as their object the production of bolts having at least the mechanical properties of those made of medium alloy steel, but whether or not the nut can be made of the same alloy remains to be seen. Pending the solution of this problem, of course at the cost of a definite weight penalty, Monel-metal nuts appear to provide a possible way out. It is indeed possible that some type of surface finish may yet overcome this difficulty.

Chemical Properties.—The physical and mechanical properties of the metal and its alloys having been considered, it now remains to deal with those of a chemical nature. Here again, the work which has been carried out is all too limited, particularly as regards contact corrosion, to allow of any dogmatic utterance. There is, however, one well-

* Paper read before Section G of the British Association at Liverpool, on Tuesday, September 8, 1953. Abridged.

* Bibliographical references will be given at the end of the paper.—Ed. E.

established fact—titanium and its alloys are resistant to a remarkable degree to seawater, even up to those temperatures which are experienced in a steam condenser. Subject, therefore, to commercial and to several other technical considerations, it is of very definite interest to the marine engineer—for example, with a water speed on the interior of a condenser tube of 40 ft. per second its resistance to corrosion is better than that of 70 : 30 cupro-nickel under like conditions, while in the form of a propeller it withstands cavitation attack extremely well. Further, its indifference to seawater even in a state of high turbulence suggests that, as the material for "A" brackets of small high-speed craft, it should receive consideration.

A table indicative of corrosion resistance is virtually impossible to construct—the number of known chemical compounds is astronomical, while the permutations of their mixtures, including variations in concentration and temperature, are virtually limitless. For the benefit of the chemical engineer, a note published by the Titanium Metals Corporation[2] may be consulted. It at least indicates both the strength and weakness of titanium as regards chemical attack.

Engineers, whether chemical ones or not, will ask, as the lawyers say, for "further and better particulars." All will have in mind the question of contact corrosion, ever an important question when, as not infrequently happens, mechanisms or structures are not homogeneous but are made of dissimilar metallic materials. To date, the experimental information is not wholly satisfactory. There are, however, certain observations which are reasonably well founded. Generally speaking, when commercially-pure titanium or one of its many alloys makes contact with another metallic engineering material in the presence of an electrolyte, it is not the titanium which suffers. It is the engineering metallic material that it physically touches that is more likely to be the victim of this embarrassing type of electro-chemical attack. Finally, at about 600 deg. C., the metal will begin to react with nitrogen, oxygen, steam, carbon monoxide and carbon dioxide. With increasing temperature, the rate of chemical attack will, of course, be more rapid, but in the case of nitrogen, reaction will not be vigorous below 1,000 deg. C.

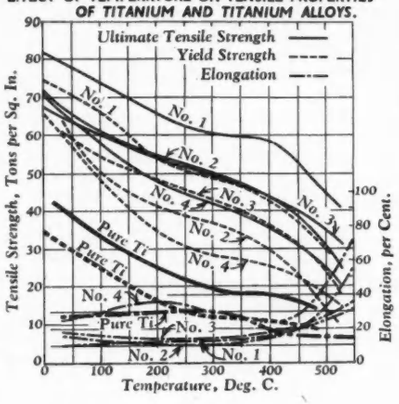
Workability.

The foregoing may have at least created the impression that the engineer cannot be indifferent to titanium. What has been disclosed shows that the metal and its alloys give promise of some high specific mechanical properties, together with considerable resistance both to direct chemical attack and to the more insidious galvanic one. For the benefit of the production engineer it is now necessary to consider the workability of the new metallic material. This involves a brief review of such matters as casting, forging, extrusion, welding, machining, cold forming, pressing, etc.

Casting.—At present, though not necessarily for all time, really satisfactory castings cannot be made in titanium or titanium alloys. The fundamental reason for this is that all materials which have so far been used for mould making have been found to be attacked in varying degrees by the molten metal. Should this difficulty be solved, however, titanium founding will probably prove to be a somewhat complex matter. The molten metal, in addition to its attack on all mould materials so far tested, combines with vigour with hydrogen, nitrogen, oxygen, steam, carbon monoxide and carbon dioxide. This chemical activity would appear to make special melting and casting techniques essential. They might be carried out *in vacuo* or probably with lesser technical difficulty in an atmosphere of one of the inert gases, such as helium or argon. It is, however, but fair to add that using "skull" melting in an inert gas atmosphere, titanium castings have, in fact, been made. The surface pick-up from the mould has given rise to a brittle outer layer to the casting, which for certain applications, would have to be removed by mechanical means.

Forging.—In all forging operations, the forger, within limits, uses the highest temperature possible in order to obtain the maximum degree of plastic deformation for the minimum amount of mechanical effort. Due, however, to the intense chemical activity of titanium and its alloys, their forging temperature has to be in the range of 880 deg. to 980 deg. C. Unless heating is carried out in an inert atmosphere, some scale will be formed and this will, in the case of drop forgings, tend to reduce the life of the dies. Though, by the use of a controlled atmosphere the heating operation could be done without scale formation, this would, of course, involve additional expense. Roughly speaking, when heated to the temperature indicated above, the mechanical effort required to forge commercially pure titanium and its alloys is comparable with that used for alloy steel forged at about 300 deg. C. higher, but the die wear with the new material will normally be greater. Some of the two-phase alloys are subject to grain growth. The reduction of this difficulty to a minimum is best

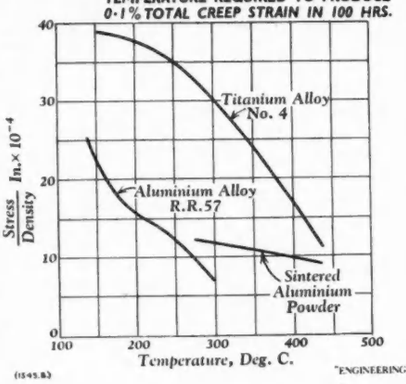
Fig. 1.
EFFECT OF TEMPERATURE ON TENSILE PROPERTIES OF TITANIUM AND TITANIUM ALLOYS.



Alloy No. 1 = Ti + 3% Al and 5% Cr
" No. 2 = Ti + 7% Mn
" No. 3 = Ti + 4% Al and 4% Mn
" No. 4 = Ti + 2·7% Cr and 1·3% Fe

(1548.A) "ENGINEERING"

Fig. 2. VARIATION IN SPECIFIC STRESS WITH TEMPERATURE REQUIRED TO PRODUCE 0·1% TOTAL CREEP STRAIN IN 100 HRS.



(1549.B) "ENGINEERING"

achieved by quick heating and heavy reduction per heat—subsequent heat treatment may also be beneficial in bringing about phase transformation and thus increasing stability.

Extrusion and Cold Drawing.—The hot extrusion of titanium and its alloys, given suitable die lubrication, presents little technical difficulty. One interesting die lubricant is molten glass—the process in which it is the feature is known as "Sejournet." If the titanium billet is given a surface sheath of brass, copper or even soft iron, this greatly facilitates extrusion, but the subsequent removal of this superficial metal is a matter of some difficulty. Cold drawing to size is something of a problem. If the metal during the cold operation is covered with a certain degree of scale, few troubles are experienced, but if the amount of scale is inadequate, pick-up will occur. Then nothing can be done but stop the operation and re-heat in air, thus re-creating the essential pick-up preventing scale.

Welding.—Welding of titanium and of its alloys has to be carried out under conditions which prevent chemical reaction between the hot or molten metal and the surrounding atmosphere. Heli-arc or argon-arc or a combination of the two thus becomes ideal for the purpose. There are, however, several additional difficulties which have to be faced. Due to the surface embrittlement which, as a result of chemical reaction, heating in air produces in hot or molten titanium and its alloys, the welding operation requires an inert atmosphere, not only on the working face of the metal being welded, but also on the reverse—in other words, there has to be an inert gas feed to both sides of the metal during welding. With commercially-pure titanium and with the single-phase alloys of the metal, such a modified heli-arc or argon-arc technique produces extremely satisfactory welds, having an ultimate tensile strength and ductility of the same order as the basic metal. If, on the other hand, the alloy which has to be welded is a two-phase one, heli-arc or argon-arc will give satisfactory welds, merely from the tensile aspect, their ductility ordinarily being disappointing.[3] This is generally regarded as being the case if flash welding is employed, but one authority, Brown,[4] exceptionally finds that ductile flash welds can be made in two-phase titanium alloys. Spot welding of commercially-pure titanium sheet has received some investigation in this country,[5] but though the results obtained can be regarded as encouraging, far more investigation is required before the possibilities and limitations of the method can be correctly assessed.

Machining, etc.—The machining of titanium and its alloys at present is difficult—more so than the carrying out of similar operations on 18 : 8 austenitic steels. Ideas as to the best tool materials, shapes, cutting speeds, lubricating, coolants, etc., are definitely in a state of flux. A good summary of current views is given in a publication of the Titanium Metals Corporation of America.[3] One novel idea therein which is both ingenious and effective might be mentioned. Broken-in drills or taps can be dissolved out by heating in a strong aqueous solution of ferric ammonium sulphate. This is almost without influence on the titanium, but is, of course, an iron solvent.

Cold Pressing.—At the present state of knowledge it seems to be generally agreed that commercially-pure titanium can be deep drawn to about the same extent as low-carbon steel. More annealings will, however, generally be necessary. Further, greater hold-down pressures and lower press speeds will be required. With titanium alloys, as their ultimate tensile strength increases, greater difficulties are, of course, experienced in forming operations. Comparatively small increases in temperature above the ambient one, say 250 to 350 deg. C. can, however, greatly facilitate difficult press operations.

Riveting.—Rivets made of commercially-pure titanium are the subject of current experiments. The machine-made head can certainly be satisfactorily produced at room temperature, but the one which has to be formed on the job has, to date, not always been entirely satisfactory. Further, it has to be seen whether the well-known picking-up tendency of titanium does not in the case of rivets assert itself under their heads. If this is the case, the fatigue characteristics of titanium riveted joints are likely to be decreased by this.

TABLE V.—*Mechanical Properties and Prices of Commercially Pure Titanium and Titanium Alloys, Per Long Ton.*

COMMERCIALLY-PURE TITANIUM.	
Approximate mechanical properties:	
0·2 per cent. proof stress	34 tons per sq. in.
Ultimate stress	39 tons per sq. in.
Elongation	23 per cent.
TITANIUM ALLOYS.	
Approximate mechanical properties:	
0·2 per cent. proof stress ..	36 to 71 tons per sq. in.
Ultimate stress	49 to 90 tons per sq. in.
Elongation	19 to 6 per cent.
PRICES.*	
Hot-rolled bars, simple forgings, rounds, discs, etc.	7,900*l.* per ton, or 3·53*l.* per lb.
Annealed sheet and strip	11,900*l.* per ton, or 5·32*l.* per lb.

* Calculated at the rate of 2·82 dols. to the pound sterling.

RETAIL HANDLING OF COAL AND COKE.

FIG. 1. BULK-DELIVERY VEHICLE DISCHARGING INTO STOCK.

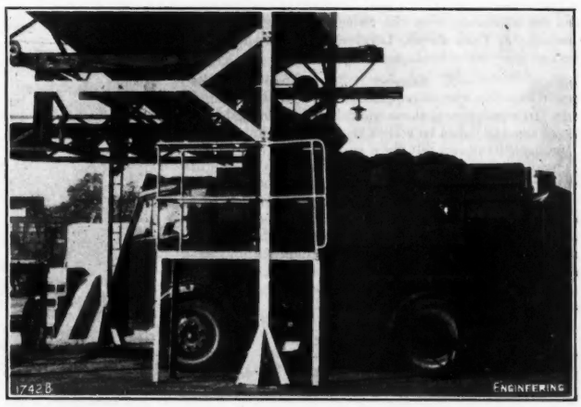


FIG. 2. BULK-DELIVERY HOPPER LOADING A LORRY.

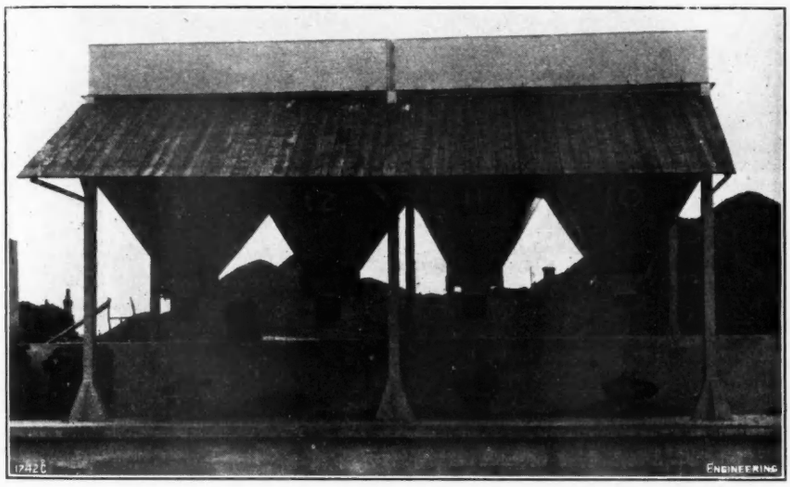


FIG. 3. STAND OF FOUR HOPPERS FOR FILLING SACKS BY WEIGHT.

Cost.—Very much more could be written with regard to the workability of titanium and its alloys. The writer, however, feels that what has been disclosed should create in the mind of the engineer the idea that their physical, chemical and mechanical properties are sufficient largely to outweigh such difficulties of fabrication as at present exist—in fact what has been said, it is hoped, shows that these new materials, subject to the all important question of price, have engineering applications. At the present time, the cost of the commercially-pure metal and of the alloys is the same, though, as can be seen in Table V, opposite, there are substantial differences in their respective mechanical properties. The prices given are New York ones; they would be considerably augmented in this country, for increases would have to be made on account of packing, land and sea freight and Import Duty. Moreover, the basic price of the metal is higher when the quantity purchased is small.

(To be continued.)

BIRMINGHAM CLOCK AND WATCH EXHIBITION.—An exhibition of British clocks and watches, and the machinery used in their manufacture during the past 300 years, was opened on Friday, October 30, by Sir Harold Spencer Jones, F.R.S., the Astronomer Royal, at the Birmingham Museum of Science and Industry, Newhall-street, Birmingham, 3. The exhibition, which will remain open until February 28, 1954, includes some rare timepieces, and a variety of machine tools, press tools, and other equipment used in their manufacture. The manufacturing equipment is representative of both obsolete and modern methods. Some of it has been lent by firms engaged in the manufacture of clocks and watches, and illustrates current British practice.

EQUIPMENT FOR THE RETAIL HANDLING OF COAL AND COKE.

IN our issue of May 16, 1952 (page 616, vol. 173), we illustrated and described a coal bulk-delivery lorry with a capacity of 5½ tons, as developed by Charrold, Limited, Tower House, 40, Trinity-square, London, E.C.3, for the delivery of coal, coke, etc., to those premises which do not permit the entry of tipping lorries. A further development is the recent introduction of the Atkinson 14-ton Charrold bulk-delivery vehicle, which is shown in Fig. 1, on this page, discharging its contents into stock. In many respects this larger vehicle is similar to the smaller one, in that a hopper-type body is fitted, in the base of which is a scraper conveyor driven through a take-off from the car transmission. A separate detachable conveyor receives the material as it is discharged by the scraper conveyor and delivers it at the point required. The detachable conveyor may be turned through an angle of 180 deg. for delivery purposes and can be set to stack up to a height of 10 ft. When not in use, the conveyor is stowed and carried in brackets along the off-side of the vehicle and immediately above the rear wings. Power is provided by a hydraulic motor, the pump being driven from the engine of the vehicle; the flexible pipes leading to the motor on the conveyor are clearly shown in Fig. 1. An advantage claimed for this vehicle is that since the body is divided into compartments, it can deliver part loads of known weight, and can also draw from different compartments at the same time and effect a blending of different coals while delivering.

Charrold, Limited, which is a Charrington company devoted to material handling by new methods and under modern conditions, have also recently developed static equipment which has been put into service at the retail coal depot at Cambridge of Austin, Beales and Company, Limited, also a Charrington Company. This equipment is the outcome of combining into one mechanised yard the previous three yards of Coote and Warren, Limited, P. Beales and Company, Limited, and Austin and Company, Limited. Many systems incorporating wagon-tipplers, radial conveyors, gravity feed hoppers, etc., were examined in relation to the existing positions of sidings and access roads, before two hoppers for loading bulk-delivery vehicles in the manner illustrated in Fig. 2, and eleven hoppers for filling bags by weight, as illustrated in Fig. 3, (which shows a stand of four of these hoppers) were decided upon and erected.

All hoppers are filled by means of a Jones K.L. 44 crane and a grab which unload from wagons and handle the fuel between the hoppers and stock-piles. The two hoppers for loading bulk-delivery vehicles were primarily designed for that purpose, but may be used for filling bags. The horizontal conveyor is therefore provided with two speeds and an electromagnetic brake to give the necessary speed of cut-off when bags are being filled. The horizontal conveyor is mounted in a frame which has a traverse of 8 ft. and thus permits a bulk-delivery vehicle to remain stationary while it is being uniformly loaded over its length. The time required to load a 5½-ton bulk-delivery lorry is about five to ten minutes only, thereby greatly reducing idle time. Each of the hoppers used for filling bags by weight holds 7 tons and at each exit is a screening device which separates out the dust and slack from the fuel being bagged. The control gate is arranged horizontally and is said to give very accurate control over every kind of fuel discharged, from anthracite grains upwards; moreover, it does not take up so much height as the more normal vertical type. The speed of filling bags is high and two men, one filling and one loading on to the waiting lorry, can accurately weigh and load 50 cwt. into 50 bags in 15 to 20 minutes, from one hopper.

CRYSTAL PALACE TELEVISION TRANSMITTING STATION.—Contracts have now been placed with Marconi's Wireless Telegraph Co., Ltd., Chelmsford, for the construction of two 15-kW vision and two 4·5-kW sound transmitters. These are to be installed in the new television station on the Crystal Palace site in South London. By the use of a high-gain aerial system, the station will be capable of producing an effective radiated power of about 250 kW, compared with 34 kW for Alexandra Palace and 100 kW for the other high-power stations in the country. This aerial system will be erected on a 640-ft. mast, which will raise it to about 1,000 ft. above sea level. The transmissions will be vertically polarised and will be on the same frequency as those used at Alexandra Palace, namely, 45 megacycles for vision and 41·5 megacycles for sound.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2, Park-street, London, W.1, at the price quoted at the end of each paragraph.

Copper Tubes.—A number of specifications for copper tubes for special applications have been published. In most cases, these include fully-dimensioned tables of sizes of tubes to which the specifications apply and the need has been felt for a specification for copper tubes which would meet the requirements of general users who find it difficult to select suitable sizes from the dimensional tables in existing specifications and who may often prefer to specify copper tubes by the outside diameter and thickness required. The outside diameters are normally expressed in inches and fractions of an inch and the thicknesses in imperial standard wire-gauge numbers. A new specification, B.S. No. 2017, it is believed, should meet the need indicated, including, among others, those of users in the motor-car, petroleum and refrigeration industries. In many instances, tubes are required for connection by fittings involving a close fit between the outside of the tube and the socket of the fitting. It has been considered desirable, therefore, to include two ranges of tolerances on outside diameters, namely, the usual plus and minus tolerances and a limited minus tolerance. With a view to promoting a reduction in the number of sizes demanded, the compilers hope that users will endeavour to select their tube sizes from a list of preferred sizes given in an appendix. [Price 3*s.*, postage included.]

Copper Plate.—Another new specification, B.S. No. 2027, deals with rolled copper plate in the annealed condition in thicknesses over $\frac{3}{8}$ in. and over 12 in. in width. The quality of the material, tolerances and mechanical properties are specified and details of mechanical testing procedure are included. [Price 2*s.* 6*d.*, postage included.]

Methods of Protection against Corrosion for Light-Gauge Steel Used in Building.—A revision of a publication designated P.D. 420 has now been issued. First made available in November, 1945, it is concerned with "Recommendations on Methods of Protection against Corrosion for Light-Gauge Steel Used in Building." The publication deals with the protection of mild-steel components not exceeding No. 10 s.w.g. (0·128 in.) in thickness used in general building construction. The procedures recommended are not mandatory, but are intended for the guidance of those concerned with the protection of light-gauge steel. Six grades of protection are recommended, comprising a thick metallic coating and two coats of paint, a thin metallic coating and two coats of paint, a phosphate coating and three coats of paint, a flash metallic coating and two coats of paint, a phosphate coating and one or two coats of paint, and, finally, simply one or two coats of paint. The importance of avoiding design and structural details conducive to corrosion is emphasised. [Price 3*s.*, postage included.]

Dimensions of X-ray Films for Crystallography.—A new specification, B.S. No. 2030, is concerned with the dimensions of X-ray films for crystallography. It has been prepared to deal with the sizes of X-ray film used in the various instruments peculiar to the crystallographer such as the diffraction powder cameras specified in B.S. No. 1693. The specification is intended to be a guide to the future design of equipment and apparatus, and it is hoped that it will encourage X-ray crystallographs to adopt the specified sizes wherever practicable. [Price 2*s.*, postage included.]

Black Bolts, Screws and Nuts.—The main purpose of a revision of B.S. No. 916, first published in 1940 as a war-emergency specification, is to take account of current practice in the manufacture and use of black bolts and nuts. To give it its full title, the specification covers "black bolts, screws and nuts, hexagon and square, with B.S.W. threads, and partly-machined bolts, screws and nuts, hexagon and square, with B.S.W. or B.S.F. threads." It is recognised that, during the transition period which must elapse before the adoption of Unified threads becomes general, B.S. No. 916 will continue in use. The compilers state, therefore, that it is obviously desirable that the general requirements for the bolts and nuts covered by the present specification should be consistent with those given in B.S. No. 1769, which deals with Unified black hexagon bolts, screws and nuts—heavy series. In addition to specifying dimensions and tolerances for bolts, screws and nuts from $\frac{1}{4}$ in. to 6 in. inclusive, the specification includes requirements for material, squareness of thread to face of nuts, recommendations for drilled bolts and split-pin holes, the dimensions of plain steel washers for bolts of up to 2 in. nominal size, and the nominal stock lengths of hexagon-head black bolts in diameters up to 1 in. [Price 3*s.*, postage included.]

JACKING UNIT FOR PRESTRESSING CONCRETE.

CABLE COVERS, LIMITED, LONDON.

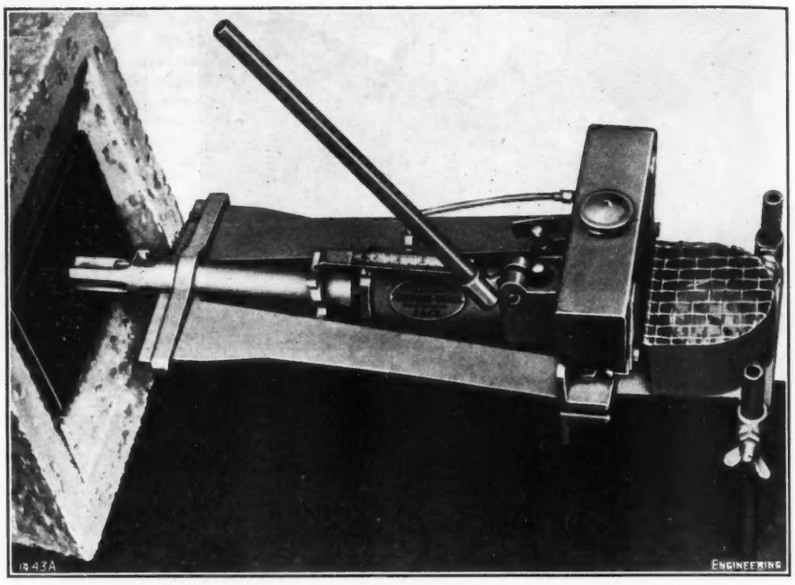
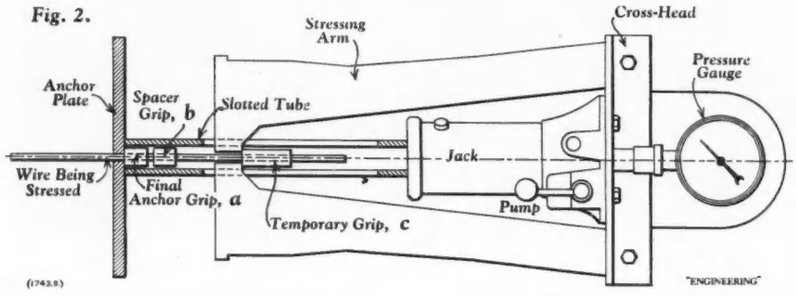


FIG. 1.



LIGHTWEIGHT JACKING UNIT FOR PRESTRESSING CONCRETE.

THE accompanying illustrations, Figs. 1 and 2, show a small compact pump and jacking unit devised for tensioning wires one at a time for prestressed concrete. The unit can be used to tension any standard size of wire up to 0·276 in. in diameter. For post-tensioning, the wires are arranged in groups of any number up to twelve and are placed in either 2-in. diameter or $1\frac{1}{2}$-in. diameter ducts with spacers at intervals of between 3 ft. and 6 ft., according to the curvature of the cables; these spacers assist the flow of grout and prevent the wires from binding against each other during the stressing operation. At the ends of the beam, or of the member being prestressed, the wires are contained in a funnel which permits them to spread out from the close formation within the duct to the wider spacing on the drilled steel anchor plate that accommodates the anchor grips and the head of the jacking unit.

The jack has been developed by Mr. E. W. H. Gifford in conjunction with J. J. Udall's Building Company, Limited, West Quay-road, Southampton; the anchor grips employed are produced by Cable Covers Limited, St. Stephen's House, London, S.W.1, who will also make the jacking units and be responsible for their sale and distribution. The anchor grips consist of small steel housings, of the same external diameter irrespective of the size of the wire, the wire being held by serrated inserts which combine a wedge action with a mechanical grip to give a secure fastening.

As can be seen from the illustrations, the jacking unit consists of a simple ram which thrusts a slotted tube against the anchor plate of the member being prestressed, the wire being temporarily held behind the stressing arms by grip *c*. By working the jack, the stressing arms are forced away from the anchor plate, so extending the wire. During the process of straining, the final anchor grip *a* is loose on the wire and, with the spacer grip *b*, is held in place by a key (not shown in Fig. 2); when the required strain has been achieved, the key is removed and a drift, bearing on the spacer *b*, is inserted in its place. This drift is used to drive home the wedge inserts into the anchor grip *a*; the jack pressure is then released and the jack removed. The wire is cut off close to the final grip and the temporary grips, *b* and *c*, retrieved for further use. The extension of the wire is measured against an adjustable rule and the load read off a direct-reading pressure guage; with the standard unit, it is possible to obtain an extension of $4\frac{1}{2}$ in., but this can be increased by using an alternative slotted tube. In Fig. 1, the jack is shown with a small oil reservoir built above the pump.

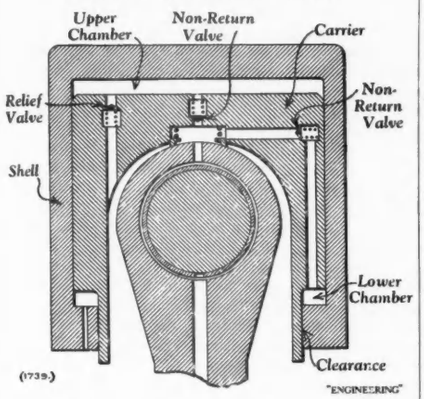
The features of the unit are low weight—only 56 lb.—and the speed and simplicity of operation, which will allow one man to tension and anchor wires at the rate of about 20 per hour. Such a pump as this, together with the anchor system employed, brings prestressing of concrete, with all its advantages, within the scope of the small contractor or, for the larger contractor, makes prestressing an economical proposition on comparatively small jobs.

INTERNAL-COMBUSTION ENGINE RESEARCH.

THE British Internal Combustion Engine Research Association, Slough, Buckinghamshire, held their demonstration and open days on October 15 and 16. Many interesting demonstrations and exhibits were arranged, covering the wide field of research that is carried on at this station. Much of the work is of a long-term nature; some of the wear and corrosion tests have involved 27,000 hours running, and consequently definite conclusions cannot yet be given. For example, work is being done to discover the best materials for use with Class B fuels in high-speed Diesel engines; wear rates have been much reduced and the use of such fuels is becoming a commercial possibility. Other subjects being investigated are noise reduction, stress analysis, instrumentation, bearing wear, turbo-charging, fuel-injection and combustion problems, and torsional vibration. On this last subject a full report is being prepared for circulation among members of the Association.

Development work continues on the B.I.C.E.R.A. compressor, and this field appears promising. A hydraulic servo-operated fuel-injection pump to give high rates of injection is under test, and a

B.I.C.E.R.A. VARIABLE-RATIO PISTON.



delivery valve to eliminate secondary injection and to supply pilot injection is being tried in conjunction with it. These, and the B.I.C.E.R.A. piston, are being tried with high-pressure turbo-charging. The B.I.C.E.R.A. piston is a special development to enable very high outputs to be obtained without exceptionally high maximum pressures, and to give a high compression ratio for easy starting with an automatic reduction as the m.e.p. increases. A diagrammatic cross section is shown in the diagram above. The piston consists of an inner carrier in which is the gudgeon pin, and an outer shell mechanically free to move up and down, but hydraulically limited by the oil in the space at the top and the annulus at the bottom. This oil is supplied from the ordinary lubricating system through the little-end and the two non-return valves. Thus the full gas load is carried by the oil in the upper chamber, but when it exceeds a predetermined value, the relief valve opens and the oil is discharged into the cylinder. This allows the shell to move downwards, with a reduction of compression ratio, and therefore of gas pressure, till equilibrium is reached. If the gas pressure above the piston is reduced, as when the engine is throttled, then oil from the annulus is forced out through the clearance between the shell and the carrier. The inertia forces at the end of the stroke cause this to happen and a few cycles are sufficient for full movement of the shell. During steady running the shell moves up and down a very small amount during each cycle; this ensures that the compression ratio remains correct, and also causes a constant flow of oil through the system, preventing overheating and carbonisation. The system is capable of dealing with sudden changes of gas load.

This piston was originally developed for use on a petrol engine, but it has proved adaptable to the compression-ignition cycle. If the piston crown is symmetrical in form, the shell can be allowed to rotate on the carrier, eliminating the "thrust side" and giving more even wear. Asymmetrical pistons can be keyed to the carrier without introducing any difficulties. In tests so far carried out on a single-cylinder petrol engine, a fuel reduction of over 30 per cent. has been achieved at about 25 b.m.e.p. The range of compression ratio was from 16 to 1 to 8 to 1. Since most vehicular engines run at part throttle for the greater part of their lives, this represents a very large economy. However, as yet the gains are not constant over the speed range and experiments are continuing. They are being extended to the turbo-charged high-speed Diesel mentioned earlier and to a six-cylinder car engine. Preliminary tests carried out have been encouraging.

ONE-MAN OPERATED 'BUS.

LONDON TRANSPORT recently took delivery of a new 26-seat single-deck 'bus. It will be classified as the G.S. type and a number of them will be used to replace the Leyland "Cubs" which have been in service for 18 years. The new vehicle was specially designed and constructed by Guy Motors, Limited, Wolverhampton, and Eastern Coach Works, Limited, Eastern-way, Lowestoft, in collaboration with the design staff of London Transport Executive. The chassis is basically a Guy "Vixen" of 15-ft. wheelbase. The engine is a Perkins P.6 with a Borg and Beck 11-in. diameter clutch and the gearbox is a Guy four-speed unit; it drives a spiral-bevel rear axle of 5·7 to 1 ratio. The fuel tank has a capacity of 18 gallons and is mounted on the nearside of the chassis. A hinged flap is provided at the front of the bonnet for direct access to the radiator cap. At the extreme rear of the chassis provision is made for a 24-volt battery. The body is constructed of light alloys and is riveted. The interior decoration conforms as nearly as possible with standard London Transport practice and although the vehicle is considered non-standard, many standard production units have been incorporated.

To enable one man to operate the vehicle a jack-knife type of folding door has been fitted; it can be operated from the driving seat by means of a C.A.V. electrical control. A partition has been built on the nearside of the driver to incorporate a ticket-issuing machine mounted on a hinged flap, which forms the door of a locker. The machine can therefore be locked away by pushing up the flap. The partition also serves as a guard for the gear-change lever. A heater and demister with four outlet nozzles are installed in the cab. The external finish on the body is the country 'bus green livery and cream.

H.M. CRUISER "MAURITIUS."—After nearly two years in the Tyne undergoing refit at the yard of Palmers Hebburn Co., Ltd., the 8,000-ton cruiser Mauritius has been towed from the Tyne to Portsmouth where she will be maintained in reserve. The vessel was built at Wallsend by Swan, Hunter, and Wigham Richardson Ltd., and completed 13 years ago.

THE LATE MR. W. J. BASSETT-LOWKE.—It is with regret that we note the death, on October 21, of Mr. Wenman Joseph Bassett-Lowke, managing director of Bassett-Lowke, Ltd., model engineers, St. Andrew's-street, Northampton. He was born in 1877 and after attending All Saints' Commercial School became an apprentice in general engineering under his father. He afterwards served for a short period on the outdoor staff of Crompton & Co., Ltd. It was during his apprenticeship that Mr. Bassett-Lowke first became interested in the making of models and his enthusiasm for this branch of engineering grew with the years. In 1910, the model-making business of Bassett-Lowke Ltd., founded earlier in conjunction with Mr. H. F. R. Franklin, was incorporated as a limited company. At first, the firm occupied premises at 257, High Holborn, London, but for a number of years the head office and works have been situated at Northampton. In addition to working scale model and toy locomotives, railway equipment and ships, the firm have manufactured, in war-time, gauges and precision instruments for Government departments. Mr. Bassett-Lowke was elected a member of the Junior Institution of Engineers in 1904 and of the Institution of Locomotive Engineers in 1911.

NOTES ON NEW BOOKS.

Carrier Current on Power Lines.

By ANDRÉ CHEVALLIER. The Beama Journal. 36, Kingsway, London, W.C.2. [Price 2*s.* 6*d.*]

THE operation of widespread electric power systems requires some form of central control, so that information may be continuously available regarding the outputs of the power plants, and so that the load and its flow in one direction or the other may be anticipated and checked. Some method of transmitting information is therefore necessary and, of those possible, carrier current communication has been extensively developed in France, where there are 370 water power stations, many of which are situated far from the Post Office network. M. Chevallier has utilised his experience with the 10,850 miles of such circuits to give an informative account of the propagation of high-frequency waves along high-voltage power lines. Chapters on the establishment of high-frequency channels on such lines, on the types of telephone equipment and feeder protection used, on telemetering and fault location follow. A great deal has, of course, already been written on this subject, as is shown by the numerous references given, but M. Chevallier has provided a useful synopsis which is well worth studying.

Advanced Mechanics of Materials.

By PROFESSOR F. B. SEELY and PROFESSOR J. O. SMITH. Second Edition. John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, U.S.A. [Price 8.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 68*s.* net.]

THE first edition of this textbook for use in advanced courses of study on the strength of materials was written by Professor Seely, and published in 1932. It was characterised by a concise exposition of the underlying theory, in which attention was directed to the limitations of the elementary formulæ, and to the need for a clear understanding of the conditions under which these formulæ could be utilised in more advanced problems. Commendable care had also been taken to set down all the relevant steps in the solution of the numerous examples that had been employed to illustrate the formal analysis. For the second edition the authors have incorporated much new and useful information. The first of two new sections is devoted to the influence of small inelastic strains on the load-bearing capacity of a given structural member, especially when it is made of a ductile material. An instructive instance is provided in circumstances where the member functions satisfactorily until a small amount of plastic deformation has taken place under the action of a static load that has brought about a non-uniform distribution of direct stress. The effect of the plastic strain is a redistribution of stress that makes for an increase in the permissible load, and the authors show how this point arises in the design of a member having an abrupt change in cross-section due to the presence of a circular hole, a groove, or a fillet, and of a beam which may be either straight or curved, and subjected to combined bending and direct stress. These considerations lead to an introductory account of the ultimate load for a statically indeterminate structure; the discussion is exemplified by reference to the problem of constraints at the ends of a beam, and the stress produced in a closed ring by a concentrated load. In the second of the new parts Professor Seely and his colleague investigate the elastic and inelastic buckling of a column, and a cylindrical tube under uniform external pressure. The tangent-modulus and double-modulus formulæ for columns deservedly receive a detailed treatment, and so does the elastic buckling of a tube under external hydrostatic pressure. In regard to the buckling of a tube as a result of plastic strain, no wholly satisfactory analytical method is available for determining the collapsing pressure, but a sufficiently accurate solution for many practical purposes can be deduced from the theory of columns, as is indicated in Chapter 21. Anyone who has read the book and worked through the exercises will have a clear general picture of the subject, from which he can readily proceed to more advanced studies, since excellent lists of

references to additional sources of information have been placed at the ends of most of the chapters. Mature readers will notice, however, that Dr. E. H. Salmon's treatise on the strength and design of columns has been omitted from the list relating to this part of the treatment.

BOOKS RECEIVED.

Some Considerations on the California Bearing Ratio Method for the Design of Flexible Pavements. By R. E. KERKHOVEN and G. M. DORMON. Shell Petroleum Company, Limited, Public Relations Department, Victory House, 99-101, Regent-street, London, W.1.

Modern Developments in Fluid Dynamics. High Speed Flow. Compiled under the aegis of the Fluid Motion Sub-Committee of the Aeronautical Research Council. Edited by L. HOWARTH. Vols. I and II. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 84*s.* for both volumes.]

Syria. Review of Commercial Conditions. 1951-1952. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* net.]

Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for the Year 1951. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* 6*d.* net.]

Electricity Undertakings of the World. 1953-54. The Electrical Journal Red Book. Sixty-third edition. Benn Brothers, Limited, Bouverie House, 154, Fleet-street, London, E.C.4. [Price 30*s.*, post free.]

The Ergonomics Research Society. Symposium on Fatigue. Edited by W. F. FLOYD and A. T. WELFORD. H. K. Lewis and Company, Limited, 136, Gower-street, London, W.C.1. [Price 24*s.* net.]

DIN Normblatt-Verzeichnis 1953. Deutscher Normenausschuss, Uhlandstrasse 175, Berlin W.15. [Price 9·60 DM.]

Radio Engineering. Vol. I. By DR. E. K. SANDEMAN. Second revised edition. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 60*s.* net.]

Quasi-Arc Welding Manual. Second edition. The Quasi-Arc Company, Limited, Bilston, Staffordshire. [Price 7*s.* 6*d.*]

The Theory and Practice of Reinforced Concrete. By PROFESSOR CLARENCE W. DUNHAM. Third edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 7 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 56*s.*]

Introduction to Electron Microscopy. By PROFESSOR CECIL E. HALL. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 8.10 dols.]; and McGraw-Hill Publishing Company Limited, 95, Farringdon-street, London, E.C.4. [Price 64*s.* 6*d.*]

Engineering Drawing. By PROFESSOR FRANK ZOZZORA. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 5 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 40*s.* net.]

Budgetary Control and Standard Costs. By J. A. SCOTT. Third edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 18*s.* net.]

Betonstobning om Vinteren. With abbreviated English translation, *Winter Concreting.* By P. NERENST, E. RASTRUP and G. M. IDORN. The Danish National Institute of Building Research, Statens Byggeforskningsinstitut, 20 Borgergade, Kopenhagen, Denmark. [Price 8 kroner.]

Winterarbeiten im Beton- und Stahlbetonbau. By PROFESSOR ADOLF KLEINLOGEL. Fourth revised edition. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 12 D.M.]; and Lange, Maxwell and Springer, Limited, 242, Marylebone-road, London, N.W.1. [Price 21*s.*]

Institution of Structural Engineers. Year Book and List of Members, 1953. Offices of the Institution, 11, Upper Belgrave-street, London, S.W.1. [Price 5*s.* to non-members.]

District Heating. Parts I to V. [Price 7*s.* 6*d.*] Part VI. [Price 10*s.* net.] By the Heating and Ventilation (Reconstruction) Committee of the Building Research Board. Post-War Building Studies. Nos. 31 and 32. H.M. Stationery Office, Kingsway, London, W.C.2.

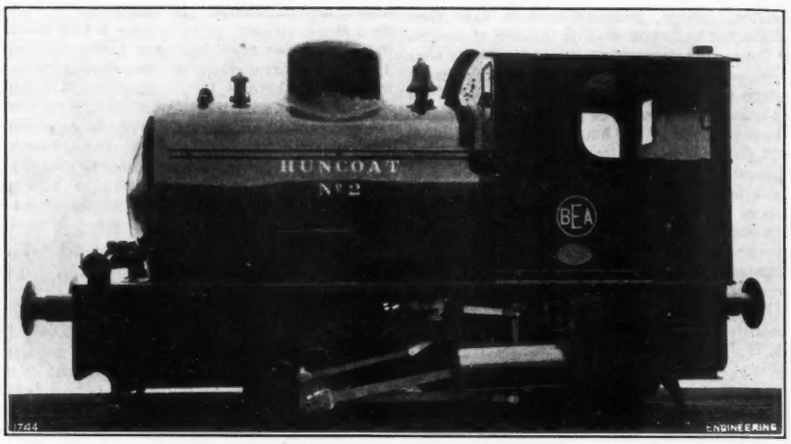
Mechanics of Materials. By PROFESSOR E. P. POPOV. Macdonald and Company (Publishers), Limited, 16, Maddox-street, London, W.1. [Price 70*s.* net.]

Theoretical Naval Architecture. By EDWARD L. ATTWOOD and PROFESSOR HERBERT S. PENGELLY. Revised by PROFESSOR ALFRED J. SIMS. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 40*s.* net.]

Productivity Report. Design for Production. Report of a Visit to the U.S.A. in 1952 of a British Specialist Team on Design for Production. British Productivity Council, 21, Tothill-street, London, S.W.1. [Price 3*s.* 6*d.*]

FIRELESS STEAM LOCOMOTIVE.

W. G. BAGNALL, LTD., STAFFORD.



TRADE PUBLICATIONS.

Finance for Exports.—The Credit Insurance Association, Ltd., Staple Hall, Stone House-court, Bishopsgate, London, E.C.3, have issued a booklet describing available facilities for export trade finance and export credit insurance.

Pitch Pine.—Mallinson and Eckersley, Ltd., Brown-street, Salford, have sent us a leaflet describing applications of long-leaf pitch pine. The company hold large stocks of this timber, which is now being obtained from British Honduras and Central America.

Synthetic-Rubber Sealing Rings.—Particulars of synthetic-rubber O-rings are given in a handbook published by the Pioneer Oilsealing & Moulding Co., Ltd., Cottontree Works, Colne, Lancashire. Sizes range from ¼ in. to 15 in. diameter and operating pressures up to 3,000 lb. per square inch. Full design data are also given.

Woodworking and Veneering Machinery.—Catalogue No. WW 653, *Woodworking and Veneering Machinery,* has been issued by F. J. Edwards, Ltd., 359, Euston-road, London, N.W.1, illustrating their range of "Besco" machines such as bandsaws, ripping benches, routers, planers, drills and a veneer-and-plywood press which includes heating and cooling arrangements.

Standard-Bicera Spark Control Unit.—A booklet has been issued by Standard Telephones and Cables, Ltd., North Woolwich, London, E.16, describing their spark control unit for use with the Farnboro' recorder. It can be used with either electro-magnetic or capacitance cylinder units, and both are included in the description. The method is fully described in B.I.C.E.R.A. report 51/5, by A. J. Cornish and W. P. Mansfield, ENGINEERING, vol. 172, page 806 (1951).

Worm Reduction Gears.—The David Brown Corp. (Sales), Ltd., Park Works, Huddersfield, have published a booklet giving details of their "Radicon" worm reduction gears. Power transmissions range from 0·03 to 220 h.p. and speed ratios from 5 to 1 up to 3,600 to 1.

Graphical Recorders.—The Record Electrical Co., Ltd., Broadheath, Altrincham, Cheshire, have published a leaflet describing a high-sensitivity graphical recorder. Standard chart speeds are from ½ in. to 12 in. per hour, and the drive can be either electric or clockwork. It can be supplied as a fixed or portable instrument.

Dial Thermometers.—The Cambridge Instrument Co., Ltd., 15, Grosvenor-place, London, S.W.1, have issued a leaflet listing their standard patterns of 4-in. and 6-in. diameter dial thermometers. There are 59 models covering the temperature range from − 10 deg. F. to + 550 deg. F.

Small General-Purpose Pump.—Sumo Pumps, Ltd., Smethwick, Birmingham, 40, have sent us an illustrated leaflet describing their latest product, a submersible pump of ½-h.p. rating designed to deliver 100 gallons of water per hour against a head of 100 ft.; its capacity against a 30-ft. head is 400 gallons per hour.

Electrical Accessories.—M.K. Electric Ltd., Wakefield-street, Edmonton, London, N.18, have published a new catalogue giving a complete list of the electrical accessories that they make, including plugs and switches for domestic and light-industrial users.

Electrical Equipment.—We have received from the General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2, a booklet giving a comprehensive list of the company's products, and of those of their associated companies and agents.

FIRELESS LOCOMOTIVE FOR HUNCOAT POWER STATION.

THE accompanying illustration shows a fireless locomotive which has been built by Messrs. W. G. Bagnall, Limited, Stafford, for use in the Huncoat power station, near Accrington, of the British Electricity Authority. As will be seen, it is of the 0-4-0 type, with wheels 3 ft. 0½ in. in diameter and a wheel base of 5 ft. 6 in. The weight in working order is 27 tons and it has been designed for running on the standard rail gauge. Instead of a boiler the locomotive has a heavily-insulated steel reservoir with dished ends, which is charged with steam from stationary boiler plant to a pressure of 250 lb. per square inch after it has been filled to a predetermined level with hot water. Subsequently, it is only necessary to charge it with steam, an operation which requires from 15 to 30 minutes. As there are no firebox, tubes or water-space stays scale is not formed and washing out is unnecessary. Such locomotives can therefore remain in service for 24 hours a day, stops only being required for re-charging. Availabilities of from 80 to 85 per cent. are therefore common. Further advantages are an absence of heat losses and small renewals, as well as, of course, cleanliness. As will be seen, the exhaust pipe is at the cab end, while the cylinders, which have a diameter of 18½ in. and a stroke of 18 in., are at the rear. The only controls are a regulator, reversing gear and brake. There are no steam auxiliaries and no loss through safety valves.

SALVAGE WORK ON FRENCH WAR WRECK.—The Admiralty Salvage Organisation is now engaged on work preparatory to the removal of the wreck of the French destroyer, Maillé Brézé, sunk in the Clyde during the early days of the late war. Early this year the Clyde Navigation Trust requested the Ministry of Transport to remove the wreck for fear that, with the passage of time, oil pollution in the Clyde might be caused either by the corrosion of the ship's structure or by another ship fouling the wreck and holing a fuel tank. In addition, there is a slight possibility of some of the ammunition becoming unstable with age, and this might cause an additional hazard should the wreck be fouled. The Ministry of Transport approached the Admiralty at the end of May with a request that the Admiralty salvage organisation should remove the wreck. This the Admiralty agreed to do. Owing to the amount of silt that has become deposited in the ship during the 13 years since she sank, the wreck will be lightened by cutting off the superstructure and removing as much silt as possible. When this has been done, lifting craft will be brought to the Clyde and the main lifting wires passed under the wreck, by means of messenger wires already in place. The wreck will then be lifted bodily on to a nearby mud bank, where the ammunition will be removed by experts and the wreck prepared for towing to a ship-breaking firm. This will probably be done during the spring and summer of next year. The salvage ships engaged are the Barrington, Barilla, Succour and Barglow.